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DUPUYTREN'S CONTRACTION

WITH SPECIAL REFERENCE TO AETIOLOGY AND IMPROVED SURGICAL TREATMENT ITS OCCURRENCE IN EPILEPTICS NOTE ON KNUCKLE-PADS

BY

TORD SKOOG

UPPSALA 1948

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From the Plastic Surgery Unit of the Queen Victoria Hospital, East Grinstead, England (Head: Sir Archibald McINDOE, M.Sc., M.S., F.A.C.S., F.R.C.S.)
and
The Surgical Clinic (Head: Professor O. HULTÉN, M.D.)
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To My Wife

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Preface

The investigation which forms the subject of this paper was started in the summer of 1946, when Sir Archibald McIndoe[1] made me the generous offer of carrying out a follow-up investigation on his outstanding material of patients treated for Dupuytren's contraction. The majority of these patients had been operated on at the Plastic Surgery Unit of the Queen Victoria Hospital, East Grinstead (England) where I was studying as a British Council Scholar. I take this opportunity of thanking Sir Archibald for the valuable help and encouragement he has given me ever since and for his kind permission to publish the first detailed account of his new operative technique in Dupuytren's contraction. My thanks are also due to the entire staff of the Queen Victoria Hospital and in particular to S/Ldr. F. T. Moore.

Since my return to Sweden, my present Chief, O. Hultén, Professor of Surgery at the University of Uppsala, has kindly afforded facilities for me to carry on the work and to widen my surgical experience in this field. His never-failing support and sound advice on various problems have been of the greatest value.

A considerable part of the investigation was carried out at the Department of Histology, Uppsala. Professor M. Wrete, Head of this Department, has most generously given much time to discussing and re-checking many statements. I am much indebted to him for the many ways in which he facilitated this part of the work.

My thanks are also due to Professor G. Dahlberg, Head of the Swedish State Institute of Human Genetics and Race Biology, for constructive criticism regarding the hereditary and statistical aspects of the problem.

In the electron microscope investigations I had the advantage of collaborating with B. E. Ingelmark, Associate Professor of Anatomy. In this connexion I also wish to express my grateful appreciation to Professor D. E. Holmdahl, Head of the Department of Anatomy, Uppsala, and to Professor T. Svedberg, Head of the Department of Physical Chemistry, for allowing me to carry out this part of the investigation at their Institutes.

I wish to acknowledge my gratitude to Professor E. Berven for his kind permission to publish a statement on his vast experience of radiation

[1] Civilian Consultant to the R. A. F., Surgeon-in-Chief to the Plastic Surgery Unit of the Queen Victoria Hospital, East Grinstead, Plastic Surgeon to St. Bartholomew's Hospital, London, etc.

therapy in Dupuytren's contraction at Radiumhemmet, Stockholm, and to Professor R. Fåhraeus, Head of the Department of Pathology, Uppsala, for allowing me to perform dissections on post-mortem material.

I am indebted to Dr. G. Waller, Chief Physician of Svenska Diakonistyrelsen's Homes for Epileptics at Stora Sköndal and Järna, who kindly allowed me to examine the patients at these institutions, and to make use of the case-records.

I also wish to convey my thanks to Miss Berta Sandén for her skilful technical assistance in the histological work, to Miss Stina Sernander for her great interest in taking the colour photographs and the clinical photographs and to Mr. A. Halvardson for the quality of the photomicrographs.

Mrs. Erica Odelberg translated the main part of the manuscript and revised the parts originally written in English. I wish to offer my sincere thanks for her accurate and painstaking work.

Financial grants have been gratefully received from the Swedish State Fund for the Promotion of Medical Research and from the Regnell Foundation of the Medical Faculty at Uppsala.

Uppsala, March 1948.

Tord Skoog.

Introduction

As long ago as 1614, PLATER described unmistakably a typical hand deformity characterized by permanent flexion of one or more fingers and most commonly seen in elderly men. Its onset is insidious and it is usually progressive in character. In 1832, DUPUYTREN in one of his famous lectures proclaimed that this deformity was produced by retraction of the palmar aponeurosis. The demonstration of this important fact has for ever associated his name with the disease. Since, however, the condition usually begins with a localized thickening of the palmar aponeurosis, which does not interfere with the function of the fingers and may remain stationary at this stage, the term "Dupuytren's finger contraction" or "Dupuytren's contraction" is inadequate. It is, however, generally accepted and will be used throughout in this paper.

After more than a century's dispute, the cause of this condition is still debated. The variety of the theories postulated illustrates in an interesting manner the trends of medical thought during the period, but cannot be said to have brought the problem any nearer its solution. Moreover, the majority of publications on the subject are more in the nature of case-histories. Theories based on such material have naturally contributed to the general confusion and today no opinion can be considered as generally accepted. As regards therapy in this disease, it is now agreed that surgical intervention alone can be expected to give satisfactory results. The large number of techniques suggested nevertheless show that this important problem has not yet been definitely solved.

The study which forms the subject of this paper was originally started as a follow-up examination of patients suffering from Dupuytren's contraction in the palmar aponeurosis, who had been treated surgically. In the course of this investigation an interesting observation was made, i. e. that a number of patients showed similar pathological changes in the plantar aponeurosis as well. The specific

nature of these changes seemed to invite a more uniform interpretation with regard to their pathogenesis. Moreover, a large number of these patients also showed nodular thickenings on the knuckles, so-called knuckle-pads. The tissue changes associated with these pads were shown to be identical with those found in Dupuytren's contraction. As a result of these clinical findings, the investigation was extended to include a more general study of the disease. As far as was possible, the pathogenesis and the aetiology of the disease have been treated separately.

The report presented here is divided into eight chapters. Chapter I is a description, based on original observations, of the anatomy and embryology of the palmar aponeurosis. This is followed (Chapter II) by a summary of the data concerning the incidence and symptomatology of the disease. Chapter III consists of original opinions on the pathological anatomy and pathogenesis based on clinical and microscopical examinations and on data obtained by the use of the electron microscope. "Dupuytren's contraction" localized to the plantar aponeurosis is considered in Chapter IV. This is followed (Chapter V) by a consideration of conditions other than Dupuytren's contraction characterized by similar changes in connective tissue. An additional report (Chapter VI) gives an account of an investigation into 207 male patients suffering from epilepsy, a disease which Lund (1941) noted was associated with a high incidence of Dupuytren's contraction. In the light of the above findings and against the background of an extensive survey of the literature, the aetiology of the disease is then discussed (Chapter VII).

Finally (Chapter VIII) methods of treatment are reviewed and an account is given of a partly new surgical method elaborated by Sir Archibald McIndoe, together with a follow-up examination of fifty cases treated by this method. Forty of these cases refer to operations performed by Sir Archibald in England and ten to operations in Sweden by the writer.

CHAPTER I

Anatomy and Embryology of the Palmar Aponeurosis

Thorough knowledge of the structure of the palmar aponeurosis is necessary in order to understand the symptomatology of Dupuytren's contraction and to perform the surgical intervention required. More general interest was aroused in these anatomical questions only after Dupuytren (1832) had demonstrated that changes localized to the aponeurosis were the cause of this deformity of the hand.

1. General Survey of the Anatomy and the Writer's Opinion Concerning the Digital Extensions of the Palmar Aponeurosis

The description of the fascial framework of the palm given in this chapter agrees in its principal traits with earlier descriptions. The writer was able to verify these by means of ten post-mortem dissections and the examination of a similar number of cases operated on for Dupuytren's contraction.

In describing this fascial system, of which the palmar aponeurosis forms a complex supporting linkage, it has been found convenient to adopt a general classification.

1. *The superficial palmar fascia* (Fig. 1), usually called ***the palmar aponeurosis***, is separated from the palmar skin by adipose tissue of a particular structure. It is triangular in shape with the point directed towards the wrist. Its longitudinal fibres consist partly of a continuation of the tendon to the palmaris longus muscle. This is, however, the most variable muscle in the human body and according to Thane (1892) is lacking in about 10 per cent or according to Kalberg (1935) in 12.5 per cent. When the palmaris longus is absent the palmar aponeurosis is attached in varying ways to the antebrachial fascia.

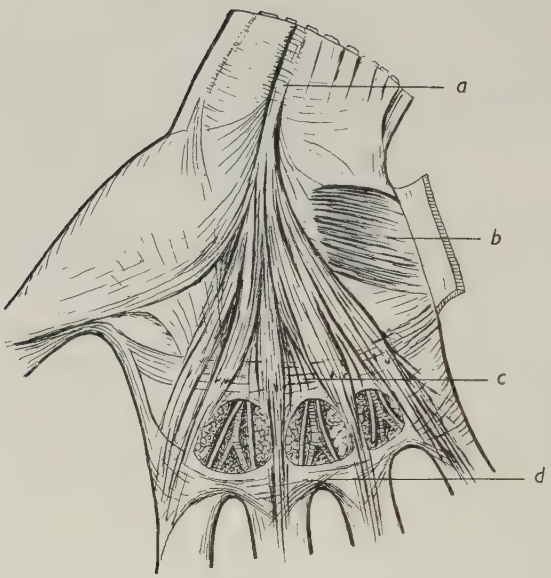


Fig. 1. Palmar aponeurosis (superficial palmar fascia); modified from POIRIER, CHARPY (1901). a — palmaris longus tendon; b — palmaris brevis; c — transverse fibres; d — natatory ligament.

The sides of the aponeurosis continue along the thenar and hypothenar regions and are reinforced in their course by two fasciculi which originate interdigited from the transverse carpal ligament. On the ulnar aspect this reinforcement consists of a marked fibrous band. The corresponding band along the thenar eminence is considerably thinner. In general, the aponeurosis is most strongly developed on the ulnar aspect.

The palmar aponeurosis is built up of fibres, which can be divided into three groups, according to their course:

a) *the longitudinal fibres* (Fig. 1) form the principal part of the aponeurosis. LEGUEU and JUVARA (1892) divided these into two groups: "les languettes prétendineuses" and, between them, the thinner "languettes intertendineuses". The former extend as four separate slips on the volar aspects of the fingers, where they partly merge into the fasciae of the fingers and partly attach to the skin. The above-mentioned writers also described two more distinct bands in the latter group, attached one on each side of the finger-base.

In one case with retraction of the palmar aponeurosis, dimpling of the skin, corresponding to the insertion of these bands, was observed.

b) *the transverse fibres* (Fig. 1) strengthen the palmar aponeurosis transversely and form, over the distal part of the palm, a distinct group. Superficial transverse fasciculi, as well as a number of oblique fibres, form the interdigital ligaments in the finger webs (Braune's or Gerdy's natatory ligaments). There is also a similar ligament in the thumb web although it is less developed and is not always in continuity with the others. Frohse (1906) differentiated between a volar and a dorsal section of these bands. Close to and proximal of the natatory ligaments are small triangular defects or considerable thinnings of the aponeurosis. When the fingers are stretched, the fat of the palm protrudes through these gaps and gives rise to the so-called *monticuli*.

c) *the superficial fibres* which run obliquely towards the skin are most numerous at the level of the metacarpal heads where they give rise to the distal palmar crease. These fibres, which unite the aponeurosis tightly to the skin, are of particular interest since this attachment produces the dimpling of the palmar skin which is often a sign of Dupuytren's contraction.

2. ***The deep palmar fascia*** covers the palmar arch, beneath the flexor tendons, and is attached to the volar aspects of the metacarpal bones. It is reinforced peripherally by transverse fibres which form the transverse metacarpal ligament.

3. ***The connexions between the palmar aponeurosis and the deep palmar fascia***, consisting of septa along the sides of the flexor tendons, are of considerable importance. These septa subdivide the middle space of the palm into eight fascial channels (Fig. 2). In four of these run the flexor tendons enclosed in their sheaths. The other four contain the lumbrical muscles as well as the common digital vessels and nerves, which are also enclosed in a separate thin layer of connective tissue. At the level of the metacarpophalangeal joints a number of septal fibres perforate to the dorsal aspect of the hand, traversing each other in such a way that the heads of the metacarpal bones can be shifted elastically in relation to each other (Fig. 3). The septa towards the muscles of the thenar and hypothenar eminences are the most strongly developed.

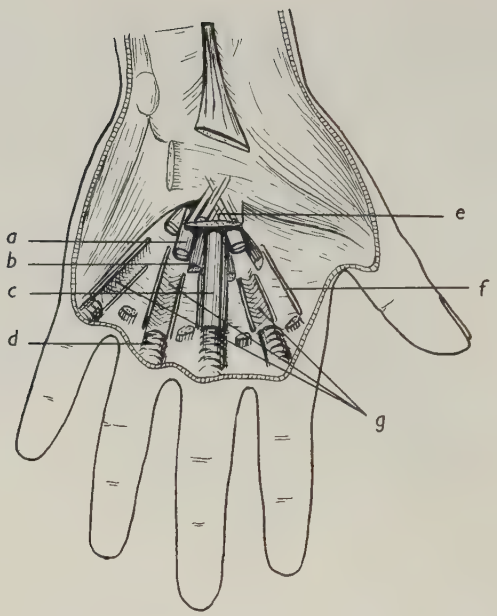


Fig. 2. Palm of hand with palmar aponeurosis removed; modified from LEGUEU, JUVARA (1892).

a — cut flexor tendons; b — proximal part of a lumbrical muscle; c — flexor tendons to middle finger left in position; d — vaginal ligament; e — deep attachments of palmar aponeurosis to transverse carpal ligament; f — deep attachment of palmar aponeurosis forming longitudinal paratendinous septum; g — deep aspect of the fibrous tendon sheaths formed by the paratendinous septa, flexor tendons removed.

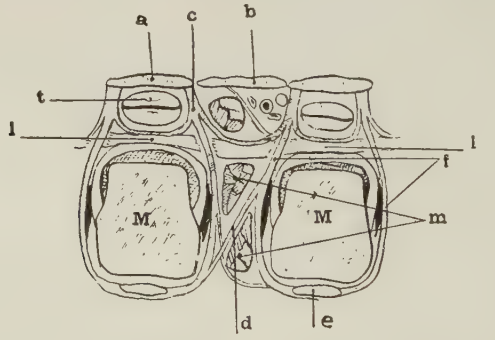


Fig. 3. Diagram showing cross section of the hand at the level of the heads of the metacarpal bones (M); from LEGUEU, JUVARA (1892). Cf. Fig. 12.

a — pretendinous band; b — intertendinous band, covering the lumbrical muscle, digital nerve and vessels (a and b together form the palmar aponeurosis); c — longitudinal septum attached to the deep palmar fascia, in this region partly penetrating the transverse metacarpal ligament (l) reaching the dorsal aspect of the hand as shown (d and f); e — extensor tendon; m — interosseous muscles; t — flexor tendons.

Dupuytren noted that the paratendinous septa which he described as bifurcations of the fascial bands for the passage of the flexor tendons are also attached to the sides of the bony proximal phalanges. There they form relatively strong longitudinal septa in continuation with the digital fascia (Fig. 4). In addition, some oblique fibres are attached to the expansion of the extensor tendon. Kanavel et al. (1929) in

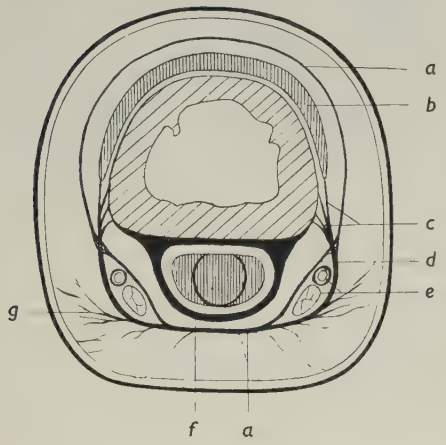


Fig. 4. Diagram of digital fascia; cross section of a proximal phalanx.

a — digital fascia; b — expansion of extensor tendon; c — longitudinal septal attachment of palmar and digital fascia to the sides of the bony phalanx and to the extensor tendon; d — deep layer of digital fascia; e — digital nerve and artery; f — vaginal ligament enclosing the flexor tendons; g — fibres to the skin.

their careful investigation of the palmar fasciae described the digital continuation of the paratendinous septa as a deep layer of the digital fascia, and regarded it as a definite structure well-defined from a superficial layer. Between these layers lie the digital nerves and vessels. *In the writer's dissections some of the fibres to the dorsum of the finger were seen running in an oblique direction, with a definite portion reaching as far as the dorsal aspect of the proximal interphalangeal joint and the base of the second phalanx. The diagram in Fig. 4, showing the arrangement of the digital fascia, is based on the writer's dissections.*

In the majority of textbooks of anatomy the palmar aponeurosis is depicted as limited laterally by the medial border of the thenar eminence. Grapow (1887) as well as other writers stated, however, that it should be possible to observe a band to the thumb crossing the pollicis brevis muscle. The question whether there is in fact an extension to the thumb is of interest, since Dupuytren's contraction can also involve this member. Later investigations show that this ex-

tension is not always present. HARPER (1935) stated that in most cases there was an extension of considerable thickness from the aponeurosis to the adjacent surface of the thenar eminence. In five cases he found that this extension was prolonged towards the metacarpophalangeal joint of the thumb. In one case it was continued into and fused with the tendon sheath of the flexor pollicis longus. KALBERG (1935) found, on dissection of 400 hands, that an extension to the thumb was lacking in 68 per cent. In his material there were also variations as regards the extensions to the other fingers. They varied in number from three to seven; thus in some cases there were two extensions to the same finger. In exceptional cases some fingers lacked an extension. In 2 per cent of such cases the extension to the ring finger was lacking. The present writer's material is too small to allow of any conclusions in this respect.

The aponeurotic tissue is poorly supplied with blood. In the present writer's normal material it was possible to observe microscopically a few fine vessels from the surface branching among the fibre bundles. From a surgical viewpoint a statement made by ANSON and ASHLEY (1940) is important, i. e. that the arteries which anastomose with the deep and superficial vessels pass through the tissue of the paratendinous septa.

Innervation is also sparse, but occurs in the form of free end-organs (Golgi-Mazzoni and Vater-Pacini corpuscles). The latter are more common and are particularly localized to the surfaces of the aponeurosis (Fig. 5). They vary considerably in size and are at times visible macroscopically. Similar observations regarding innervation were made earlier by PORSIO (1932).

Function

The palmar aponeurosis was for long regarded as a protection for the anatomical structures of the palm. DUPUYTREN mentioned its importance as a reinforcement of the arch of the hand. He was also of the opinion that it tended constantly to bring the fingers into a semi-flexed position, normally their position of repose, and believed that an exaggeration of this function gave rise to the deformity. This theory is of minor interest, but there is no doubt that the pretendinous bands counteract hyperextension of the fingers.

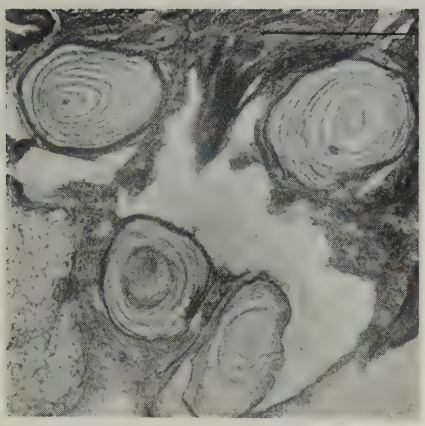


Fig. 5. Four Vater-Pacinian corpuscles. Stained with haematoxylin-eosin. Photomicrograph. (× 25.)
a — deep surface of the palmar aponeurosis.

After Dupuytren, Grapow in particular investigated the function of the aponeurosis. He was of the opinion that, amongst other functions, it contributed to ensuring the grip of the hand since the tense fixation of the aponeurosis to the skin prevents this slipping. The skin would otherwise, when gripping firmly, slide like a glove. Braune and Trübiger (1873) emphasized the circulatory significance of the aponeurosis, since by alternate stretching and relaxation it contributes to the flow of both blood and lymph. Legueu and Juvara considered that the long transverse fibres across the heads of the metacarpal bones were of particular importance in keeping the flexor tendons in position. In actual fact, this occurs solely through the strong fibrous sheaths enclosing the tendons at the base of the fingers (the vaginal ligaments). Moreover, complete excision of the palmar aponeurosis causes no bow-string effect nor any other functional disturbance of the flexor tendons. Frohse made particular mention of the importance of the natatory ligaments in preventing overspreading of the fingers and in limiting the movement of individual fingers in the metacarpophalangeal joints.

Less attention has been paid hitherto to the functional significance of the more pronounced development of the aponeurosis on the ulnar aspect. In the active phase, in movements of precision in particular, the plentifully muscled radial part of the hand is most used, whereas in gripping the ulnar region of the hand serves as a support and is particularly important in retaining a firm grip. The stronger development of the aponeurosis on the ulnar aspect as a passive protection

and supporting mechanism appears, from this point of view, as particularly suited to the purpose. It also implies greater functional strain on the aponeurosis at this site.

The framework formed by the palmar aponeurosis and its connexions retains the anatomical structures of the palm in constant relation, and its other functions, mentioned above, are also more or less evident. This does not, however, imply that the palmar aponeurosis is functionally necessary. It will be seen later in this paper that aponeurosectomy does not seem to cause any remarkable inconvenience to an adult.

2. Embryology

Little interest has been accorded hitherto to the development of the palmar aponeurosis in man. Gräfenberg (1905) states that the tendinous continuation of the palmaris longus muscle extends into the palmaris brevis muscle at an early stage. Ferrarini (1935) amongst other observations asserted that the palmar aponeurosis in the embryonic state does not extend distal to the metacarpophalangeal joints and is thus not attached to the phalanges. He considered that the transverse fibres develop independently of the longitudinal fibres.

The Writer's Observations

Since the embryology of the palmar aponeurosis has played a considerable rôle in the discussion concerning the aetiology of Dupuytren's contraction, the present writer examined systematically by means of serial sections the palmar aponeurosis of twenty human embryos and foetuses from 1.5 to 16 cm in length. The results of the investigation were as follows:

In 1.9 cm embryos the aponeurosis was seen as a well-defined plaque in the palm. It consisted of axially directed masses of cells forming a direct continuaiton and broadening of the palmaris longus tendon. At this stage it only extended somewhat proximally of the heads of the metacarpal bones. On a level with these was seen a separate proliferation of the mesenchyme with a transverse arrangement of structures from which are developed the transverse fibres characteristic of the aponeurosis in this region at the adult stage. These are thus formed independently and it is possible to observe

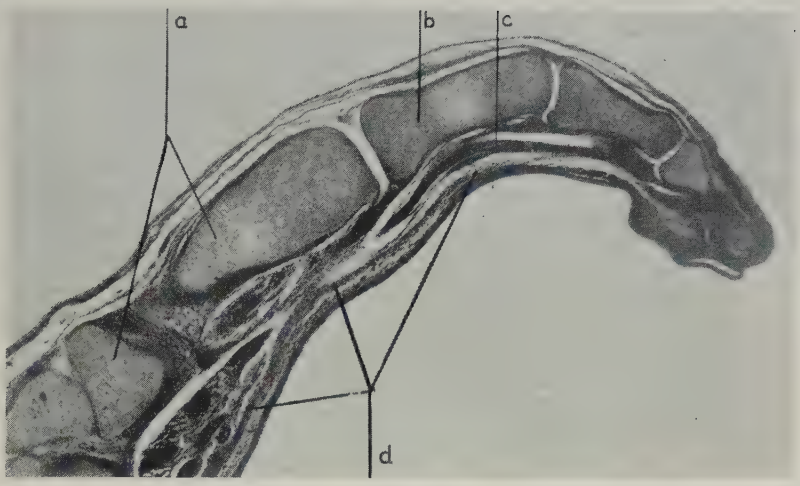


Fig. 6. Longitudinal section of the hand along the axis of the little finger in a 5.1 cm human foetus. Silver-impregnated. Photomicrograph (× 25.)
The palmar aponeurosis (d) is seen extending to the distal third of the proximal phalanx (b). a — metacarpal bone; c — flexor tendon.

during development how the extensions of the palmaris longus tendon merge with them. Already at this stage, the septal connexions between the palmar aponeurosis and the deep palmar fascia were marked.

In the 3—5 cm embryonic stage the development of the aponeurosis had continued in a distal direction, so that the digital extensions could be seen along the proximal phalanges (Fig. 6).

Figs. 7—11 show the aponeurosis in a 6.5 cm human embryo. It was possible at this stage to see how the palmaris longus tendon was attached to the transverse carpal ligament and thence spread in a manner which to a great extent corresponded to the topography of the aponeurosis in adults. In the distal part of the palm appeared longitudinal septa which divided the subaponeurotic space into fibrous canals for the flexor tendons, and between them the lumbrical muscles and the digital nerves and vessels. The particular distribution of the digital extensions of the aponeurosis and the digital fasciae could be traced already at this stage (Fig. 11). The natatory ligaments were originally formed as independent structures and only secondarily joined the aponeurosis (Fig. 10). This fact is noteworthy, since at a

state of full development the fibrous supporting mechanism of the palm is regarded as an entity.

At the 16 cm stage all the parts of the palmar aponeurosis and its connexions could be discerned. The section in Fig. 12 gives an almost

Figs. 7—11. Transverse sections at different levels of the hand in a human foetus at the 6.5 cm stage. Stained with haematoxylin-eosin. Photomicrographs.

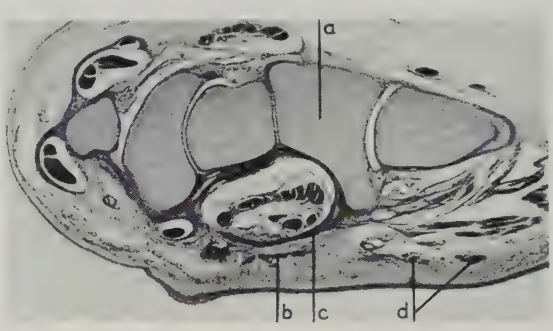


Fig. 7

Fig. 8

Fig. 7. Transverse section of the wrist showing the transverse carpal ligament (c) forming the ventral border of the carpal canal and its relationship to the palmaris longus tendon (b) superficially to it. Palmaris brevis (d) is seen as a well defined muscle strictly limited to the hypothenar region. a — hamate. (× 20.)

Fig. 8. Transverse section of the carpalmetacarpal region. The palmar aponeurosis (c) appears as a broad plaque, from which a thinner sheath (b) extends towards the thenar eminence. Note the well defined septum (a) separating the thenar muscles from the flexor tunnel. (× 20.)

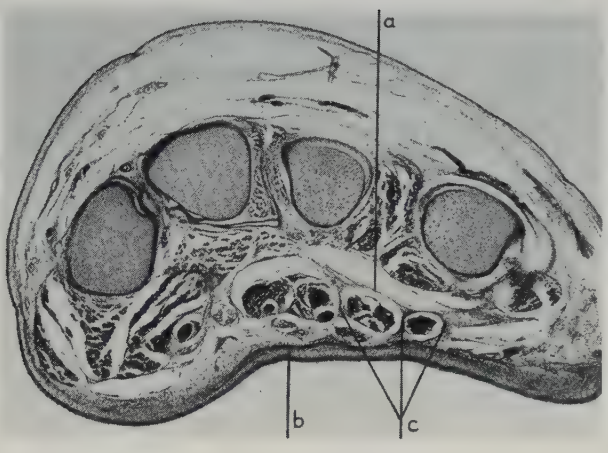


Fig. 9

Fig. 9. Section across distal part of palm. The palmar aponeurosis (b) is well developed. To the ulnar side are seen septa (c) uniting the aponeurosis with the deep palmar fascia (a). (× 20.)

Fig. 10

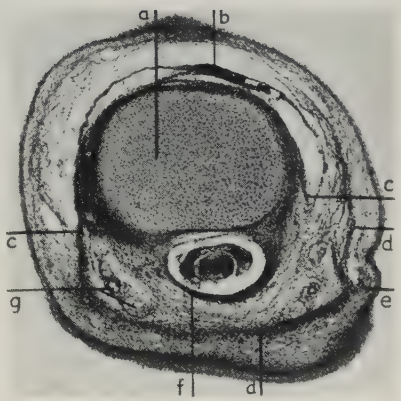


Fig. 11

Fig. 10. Transverse section just proximal to the web of the index and middle fingers. The natatory ligament (b) is well demonstrated. To the left it joins the digital extension of the palmar aponeurosis (a). (× 20.)

Fig. 11. Transverse section near base of middle finger with an almost diagrammatic representation of the arrangement of the digital fascia (d). It is strengthened by the digital extension of the palmar aponeurosis on the volar aspect and by fibres to the lateral septa (c). The latter are attached to the sides of the phalanx and to the expansion of the extensor tendon. On the deep side of the digital nerve and artery (g) there is a thin fibrous layer. (× 35.) Cf. Fig. 4.

a — proximal phalanx; e — fibres to the skin; f — vaginal ligament enclosing the flexor tendons.

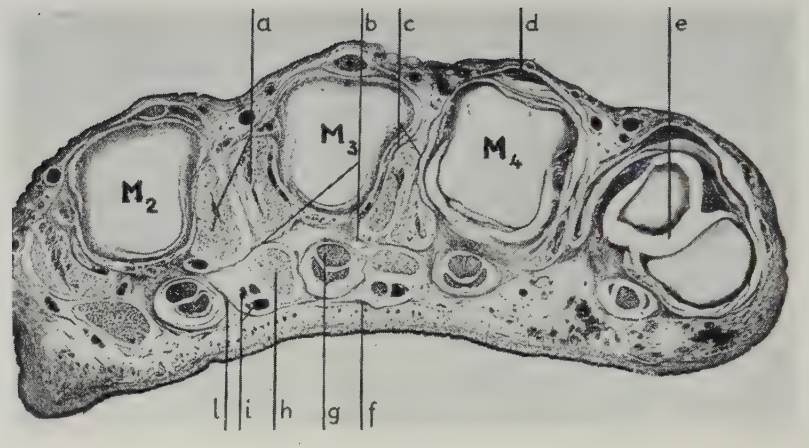


Fig. 12. Transverse section across distal part of palm in a human foetus at the 16 cm stage. Photomicrograph. (× 10.)

a — interosseous muscles; b — deep palmar fascia; c — penetrating fibres to the dorsum of the hand; d — extensor tendon; e — 5th metacarpophalangeal joint; f — palmar aponeurosis; g — flexor tendons; h — lumbrical muscle; i — digital nerve and artery; l — paratendinous septum.

schematic picture of the connective tissue framework of the palm, described previously in the fully-developed stage.

During the whole course of development the palmar aponeurosis consisted of homogeneous tissue similar to that forming tendon tissue. An increasing number of fibrillar elements appeared successively. No localized differentiations or regions reminiscent of muscle tissue were observed in preparations stained with haematoxylin-eosin or impregnated with silver.

The investigation thus supported neither FERRARINI's assertion that the palmar aponeurosis in the embryonic stage does not extend distal to the metacarpophalangeal joints, nor GRÄFENBERG's opinion regarding its connexion with the palmaris brevis muscle.

Functionally and anatomically the palmar aponeurosis in the adult stage certainly forms a homogeneous structure but its morphogenesis shows that it develops from different primordia. The significance of this fact as well as other conclusions from embryological observations will be discussed in the chapter on the aetiology of Dupuytren's contraction (p. 134).

CHAPTER II

Incidence and Symptomatology

1. General Survey

Statements in the literature give a very indefinite picture of the frequency of the disease, since only more or less selective material is found and no distribution according to sex or age has been made. Smith (1884) stated, for example, that 10 per cent of 700 inmates of London workhouses suffered from Dupuytren's contraction. It is evident that the material is selected from persons particularly likely to suffer from the disease. In comparison, some statistics from mixed patients in hospitals can be mentioned. Hedges (1896) found 1.2 per cent in 2,000 infirmary patients over 40 years of age. Anderson (1897) reported 1.3 per cent of 2,600 adult patients. Of 80,000 out-patients in a Munich hospital, Dupuytren's contraction occurred in 1.7 per cent (Schnitzler 1935). The disease usually appears in the higher age-groups and the statistics mentioned above, which give no age distribution, are thus not illuminating.

Comparisons have also been made among patients who seek treatment for this contraction and the entire number of patients at certain hospitals. The value of such investigations is, however, limited, since the number of patients with Dupuytren's contraction is to a very great extent influenced by the interest shown in this disease as well as the results of the treatment at such hospitals. Such investigations will not therefore be mentioned in this paper.

A. Sex Incidence

In the nineteenth century some authors stated that Dupuytren's contraction did not occur in women (Adams 1878, Myrtle 1881, and others). Although, however, the disease is not common in women, it has the same clinical features and can develop as severely as in men.

Unfortunately, reliable statistical material on the incidence of the condition, according to sexes, is not available. The majority of writers appear to have assumed in their series that men and women were equally represented. This may, of course, not be correct though a certain general idea of the sex incidence may be obtained even from these relatively unreliable sources.

Several writers of those listed in Table 4, p. 30, have also given the number of males and females in their series. The present writer has made a compilation of these different series, and those of OEHLECKER (1930 b), HAMANN (1938) and CLAY (1944), altogether representing 24 series with 1,820 cases. This shows a mean frequency of 89.3 $\pm$ 1.6 per cent men and 10.7 $\pm$ 1.6 per cent women; these figures representing patients who had sought treatment for their hand deformity.

Some writers assume that Dupuytren's contraction occurs more commonly in females than is usually believed, but that the disease is overlooked because it is generally less severe (HEDGES 1896, and others). It is evident to the writer that more reliable figures for sex incidence would be obtained by comparison between men and women in as nearly as possible similar social conditions and age-groups, in which the examination of both sexes had been carried out by the same worker. Table 1 shows four such statistics, taken chiefly from institutions such as workhouses in which aged and poor people from the working-class predominated. The result of this approach to the problem showed an average of 85 per cent men and 15 per cent women.

TABLE 1

Frequency of Dupuytren's Contraction in Elderly People

Author	Men		Women		Material
	Cases	Percentage of D. C.	Cases	Percentage of D. C.	
Smith (1884)	256	21.5	444	3.4	London Workhouses
Black (1915)	270	21.1	168	1.8	Nottingham Workhouse
Byford (1921)	1,000	3.4	106	2.8	Cook Country Poor Farm
Lund (1941)	199	13.0	182	2.7	Municipal Home for the Aged, Copenhagen
		Mean=14.7		Mean=2,6	

Another way to obtain information on sex incidence would be to investigate, in families with pronounced tendency to the disease, the proportions between the number of men and women suffering from Dupuytren's contraction. The material available in the literature (Table 2) is, however, small and conclusions must therefore be accepted with some reserve. The incidence in men comprised 87 $\pm$ 3.1 per cent and in women 13 $\pm$ 3.1 per cent.

TABLE 2

Frequency of Men and Women with Dupuytren's Contraction in Certain Families

Author	Cases	Men	Women
Krogius (1921)	16	14	2
Löwy (1923)	6	5	1
Apert (1925)	4	4	—
Backman, Sprogis (1925)	17	15	2
Stackebrandt (1932)	21	18	3
Schröder (1934)	46	40	6
Debrunner (1935)	8	7	1
	118	103	15

These three sets of data, though collected each on entirely different principles, show a remarkable agreement in the sex incidence of Dupuytren's contraction. We should, however, beware of making any definite conclusions for the reasons given above and since the results depend largely upon the age-factor. The statistics given are thus only intended to give a rough idea of how much more common this disease is in men than in women.

B. Age Incidence

NICHOLS (1899) examined 1,000 ex-soldiers, ranging in age from 21 to 85 years, and found that 4 per cent had Dupuytren's contraction and GERRITZEN (1936) found the palmar aponeurosis affected in 6.1 per cent of male hospital patients of various ages. As regards younger men it is a well known fact that Dupuytren's contraction among soldiers is a very rare condition (NIEHUS 1927, and others).

Contrary to this we find, in selected series of elderly men, a remarkably high frequency of occurrence. This is demonstrated in Table 1. Averaging these series, contraction was present in 14.7 per cent. It must be pointed out that material from poor-relief institutions is selective, consisting of old people and also of invalids. It therefore probably gives too high a figure for age incidence.

The influence of age is also shown by the series in Table 3. Thus of 662 cases the contraction had its onset after 30 years of age in 584 cases and after 40 in 470 cases.

TABLE 3

Distribution of Dupuytren's Contraction According to Age-Groups

Author	Age								
	Cases	0–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89
Costilhes (1885)	70	2	6	2	12	20	15	11	2
Hedges (1896)	62	—	1	11	11	17	22	—	—
Nichols (1899)	45	1	—	7	6	16	12	3	—
Byford (1921)	34	—	4	9	4	11	6	—	—
Krogius (1921).....	22	2	6	4	4	6	—	—	—
Kanavel et al. (1929)..	29	2	6	11	5	5	—	—	—
Scholle (1930)	54	1	7	9	12	15	10	—	—
Davis, Finesilver (1932)	35	—	5	9	12	6	3	—	—
Maurer (1936)	200	9	4	17	27	50	65	27	1
Horwitz (1942).....	35	—	—	3	12	14	6	—	—
von Stapelmohr (1947)	26	2	3	11	7	2	1	—	—
Skoog	50	2	15	21	7	4	1	—	—
	662	21	57	114	119	166	141	41	3

In order to form an opinion on the significance of the age factor, it would be necessary to possess statistics regarding the numbers who develop the disease compared to the distribution of the population in corresponding age-groups. As is often the case in medical work, it has not been possible to make such comparisons but only to calculate the age distribution among the patients available. In this connexion it is difficult in some series to ascertain which age is indicated, i. e. the age at which the first symptoms appeared, or that at which the patient started treatment. Moreover, we know that the disease can be over-

looked in its earlier stages. The statistics in Table 3 do not indicate the risks of contracting the disease at different ages, but the distribution of the patients in the various age-groups. The fact that there are so few old patients obviously depends on the fact that there are relatively few old people in the population. There is thus no possibility of correcting the distribution statistics to frequency statistics. We must confine ourselves to indicating the limited value of the figures. The statistics, nevertheless, clearly indicate that the frequency of the disease increases with increasing age.

The fact that the disease is so clearly correlated to increasing age has been particularly emphasized by the large number of workers who believed the changes in the aponeurosis to be caused by repeated trauma. They considered that the effect was cumulative in the course of years. MADELUNG (1875) stated that the cause was the absorption of the subcutaneous fat in the palm in elderly people, thus more easily exposing the aponeurosis to pressure and injury.

The present writer wishes, on the contrary, to draw attention to the changes in the connective tissue itself which accompany old age. It is known that these changes cause the elasticity and fluid content of the fibrillar elements to diminish (VALCARCEL 1938, and others). The significance of these changes in the physico-chemical nature of the connective tissue in relation to Dupuytren's contraction will be discussed in the chapters on the pathogenesis and aetiology of the disease.

C. Race Incidence

The forementioned statements refer to the white races. According to ANDERSON (1897) Dupuytren's contraction is very rare in Eastern countries, i. e. Japan, India and Central Asia. The disease is believed to be rare among negroes. There are, however, no definite statements available regarding race incidence.

D. Symptomatology

It is usually asserted that the disease can be either unilateral or bilateral. The largest number of cases collected hitherto (Table 4) shows that of 2,278 patients, both hands were involved in 54.9 $\pm$ 1.0 per cent; the right hand only in 29. 1 $\pm$ 1.0 per cent, and the left hand only in 16.0 $\pm$ 0.8 per cent. In order to make a statistical comparison

TABLE 4

Sex Incidence and Hands Involved

Author	Cases	Percentage of men	Bilateral	Right	Left
Keen (1881)	184	82.4	103	58	23
Smith (1885)	70	—	43	22	5
Costilhes (1885)	79	94.1	55	14	10
Hedges (1896)	62	89.1	24	20	18
Anderson (1897)	39	64.1	24	10	5
Nichols (1899)	50	—	22	12	16
Janssen (1902)	16	93.8	9	4	3
Daeschler (1903)	15	94.1	12	3	—
Heuser (1904)	61	—	37	20	4
Hume*	118	—	40	57	21
Black (1915)	240	92.1	104	89	47
Krogius (1921)	22	81.8	12	7	3
Byford (1921)	38	92.1	25	9	4
Kanavel et al. (1929)	29	93.1	17	4	8
Scholle (1930)	54	100.0	18	28	8
Davis A. (1932)	31	96.8	18	7	6
Davis, Finesilver (1932)	40	87.5	26	8	6
Wagner (1932)	19	—	15	2	2
Schröder (1934)	30	—	17	7	6
Schnitzler (1935)	117	90.0	67	33	17
Maurer (1936)	200	71.5	107	52	41
Meyerding (1936)	273	88.3	175	69	29
Deckner (1938)	60	84.6	36	17	7
Lund (1941)	209	—	121	48	40
Horwitz (1942)	35	94.3	19	12	4
Einarsson (1946)	111	91.0	53	35	23
von Stapelmohr (1947)	26	92.3	17	6	3
Skoog	50	96.0	35	10	5
	2,278		1,251	663	364
			54.9 ± 1.0 %	29.1 ± 1.0 %	16.0 ± 0.8 %

* Quoted by Black.

of unilateral cases, the cases affecting the right hand only and the left hand only were added together. Theoretically, it could be expected that the left hand would be involved as often as the right, i. e. in 50 per cent of the cases. In actual fact, the figure for the left hand is 35.4 per cent. The difference from 50 per cent is 14.6 ± 1.6 per cent

and is thus statistically significant. This difference can, however, be influenced to a certain extent by the fact that patients whose right hand is involved are more inconvenienced than in the case of the left hand and are therefore more numerous among those seeking treatment. It must also be pointed out that the division into unilateral and bilateral cases is somewhat fictitious, since the disease seldom has its onset simultaneously in both hands. There is usually a considerable interval — SCHÄFFER (1902) quoted a case in which this was 19 years — before the second hand becomes involved. It is therefore impossible to state how many of the cases reported as unilateral later became bilateral or how many of the bilateral cases were originally unilateral.

The statistics in Table 5, from 2,277 hands, show that the ring and

TABLE 5

Fingers involved

Author	Hands	Thumb	Index	Middle	Ring	Little
Keen (1881)	287	11	24	73	199	165
Smith (1885)	113	1	6	10	42	30
Costilhes (1885)	134	3	13	47	86	70
Anderson (1897)	63	4	3	22	39	28
Nichols (1899)	72	1	—	20	50	30
Krogius (1921)	34	3	1	12	31	27
Byford (1921)	63	4	1	10	35	18
Kanavel et al. (1929)	46	4	3	9	31	27
Scholle (1930)	72	1	5	10	42	28
Davis A. (1932)	49	—	—	5	27	26
Davis, Finesilver (1932)	66	3	6	14	40	43
Wagner (1932)	34	—	2	10	27	27
Schröder (1934)	47	—	1	14	27	22
Meyerding (1936)	448	21	21	88	376	314
Maurer (1936)	307	—	11	97	172	130
Deckner (1938)	96	1	2	18	47	35
Horwitz (1942)	54	1	1	7	50	50
Einarsson (1946)	164	6	10	36	87	88
von Stapelmohr (1947)	43	—	2	10	23	24
Skoog	85	11	13	34	60	65
	2,277	73	123	536	1,451	1,217
		3.2 ± 0.4 %	5.4 ± 0.5 %	23.5 ± 0.9 %	63.7 ± 1.0 %	53.4 ± 1.0 %

little fingers were affected in 63.7 ± 1.0 per cent and 53.4 ± 1.0 per cent respectively. This implies that in the vast majority of cases the disease is localized to one of these fingers.

The importance of this distribution between fingers and hands will be discussed further in the chapter on aetiology.

In this connexion, attention will be drawn to the fact that in the majority of cases reported earlier, *the first symptom of the disease was a subcutaneous nodule in the palm.* This was mentioned already by Durel (1888); Feuerstein (1936) as well as many other investigators had the opportunity of verifying this on their own hands. In fact, several modern writers regard this symptom as pathognomonic to Dupuytren's contraction.

As regards subjective symptoms, Myrtle (1881) who had long personal acquaintance with this deformity, as well as considerable professional experience, can be quoted:

"The subject of this contraction cannot wash himself with comfort, wear gloves, shake hands, carry stick or umbrella, take hold of anything or enter into many most desirable games like his neighbours . . ."

Although the disability in gripping may force many patients to give up their profession, it is remarkable how some of them become adjusted to their deformity and do not seek relief until late stages, when their fingers are crooked up into the palm.

E. Differential Diagnosis

There is generally no difficulty in making the diagnosis in Dupuytren's contraction. The pathognomonic nodular thickening and retraction of the palmar aponeurosis is not found in the following list of finger contractions which might otherwise present difficulties in the differential diagnosis.

Probably the most common errors are made in the case of congenital flexion deformity of the fingers. This deformity generally involves the little finger but may also be localized to the ring finger and shows no evidence of retracted aponeurosis in the primary stage. It is more common in women, and Gassul (1918) traced this condition through three generation in one family. A case of this type is seen in Fig. 13. (Conditions termed as congenital forms of Dupuytren's contraction, Stephenson (1885), Costilhes (1885), Greig (1919) and others, are not convincingly described. The evidence of genuine Dupuytren's contraction

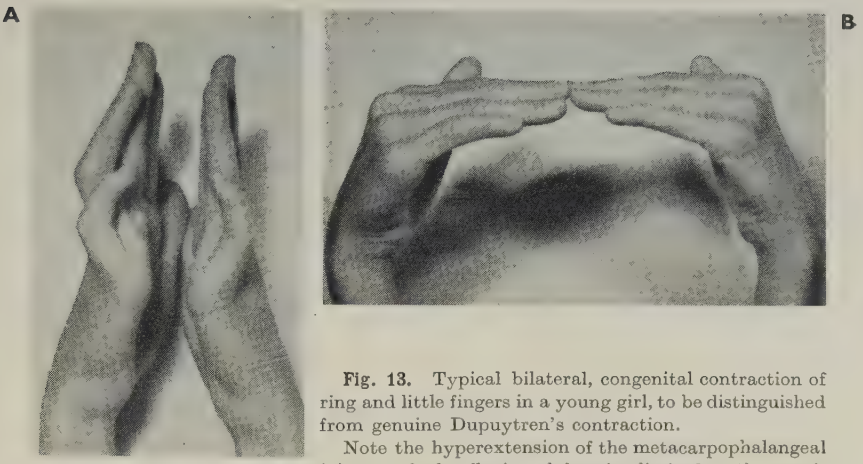


Fig. 13. Typical bilateral, congenital contraction of ring and little fingers in a young girl, to be distinguished from genuine Dupuytren's contraction.

Note the hyperextension of the metacarpophalangeal joints and the flexion deformity limited to the proximal interphalangeal joints (A). When flexed in the metacarpophalangeal joints, the fingers can be straightened completely (B).

seen in a new-born child and then followed in later years to verify the diagnosis is still lacking.)

Injuries of the palm or of the volar aspect of the fingers followed by longitudinal scars are apt to cause flexion deformity of the fingers when the scars retract. In a severe state this is also seen following third-degree burns in that area.

Finger contraction may be secondary to inflammations, especially tendovaginitis, deep infections of the palm and infections of the finger joints.

If the fingers are kept flexed for a long period, shortening of the soft tissue of the palm and the capsules of the finger joints occurs and leads to flexion deformity. This can be brought about by lengthy immobilization in plaster, paralytic conditions, severing of the extensor tendons of the fingers, or by mental disease in patients who keep their hands clenched for years, etc. Systematic physical therapy can usually cure these faulty positions of the hand, whereas it has no effect on Dupuytren's contraction.

Volkmann's ischaemic contraction should be easily recognised.

It is not unusual, in women over middle age, to find a form of polyarthritis which attacks the finger joints in particular and is therefore sometimes mistaken for Dupuytren's contraction. Inability to flex the bent fingers further, due to stiffness of the finger joints, changes in the joints demonstrable by X-ray examination, and general symptoms usually elucidate the true nature of the disease.

It is rare nowadays to find certain occupational finger contractions in which the hand has "stiffened" in the grip used to hold a tool,

and such contractions are not cases of genuine Dupuytren's contraction. Paalzow (1899) described such a deformity in shoemakers, Després in blacksmiths and carpenters. Poncet and Rollet (1888) observed among glassblowers that the handling of hot metal tubes caused chronic dermatitis in the palm, which produced crippling flexion deformity of the hand. Flexion deformities of the fourth and fifth fingers of the right hand of tailors is said to occur as a result of the position of the hand in sewing. Contractions were assumed by Hellner (1933) to occur at times through milking. Writer's cramp is a known contraction of this type. In elderly manual workers there is usually a slight contraction of all the fingers due to shrinkage of the skin and subcutaneous tissue as well as possibly of other tissues of the palm.

2. The Writer's Material

A. Age, Sex and Race

Fifty patients were examined (Table 3) 48 men and 2 women, the majority between the ages of 20 and 40 (average age 35). The comparatively low average age of this series is probably due to the selective nature of the hospital, in which a number of service patients of a low age-group were treated. The greatest age at which the condition had its onset was 66, the lowest 12. The oldest patient treated operatively was 69, the youngest 24. All patients belonged to the white races. No definite conclusions can be drawn from these facts for the following reasons: a) the material is too small and b) the majority were patients at a military hospital.

B. Symptomatology

Objective Symptoms. The disease usually began in the ulnar part of the palm near the distal palmar crease, or at the base of the ring or little finger. *In no less than 34 of the 50 patients the onset had first been noticed as a localized subcutaneous thickening in that area.* Since in the majority of cases this statement referred to events several years before the patients were examined, it is very probable that this figure is too low, especially as it is well known that the patients frequently do not observe the disease until the more advanced stage when the fingers develop contraction. In all early stages encountered by the writer a nodule was present, more or less prominent on the surface of the palmar aponeurosis to which it was firmly adherent.

Four patients reported at the onset slight tenderness of the nodule and reddening of the covering skin.

In the next stage the thickening of the aponeurosis increased and became adherent to the skin. When retracting it caused a widespread puckering in the affected area, with folds running transversely across the palm (Fig. 49 A, p. 165). Dimpling of the skin, caused by traction of isolated cutaneous bands from the aponeurosis (commonly referred to as an early sign of Dupuytren's contraction) was rare among these patients. Retraction of the diseased aponeurosis resulted in flexion of the fingers.

More usually the process first involved a part of the aponeurosis corresponding to one finger only and a longitudinal cord was formed from the nodule in the extension of that finger (Fig. 47 A). An extension of the cord running in a proximal direction towards the interthenar concavity was usually less pronounced. Several fingers were at times affected successively in the same way.

As these cords developed and retracted, extension of the fingers became limited. This could at first be overcome passively. When, however, the condition progressed, it gave rise to permanent flexion. When the fingers were drawn downwards, the nodular cords stood out somewhat like bow-strings, folding the palmar skin into ridges (Fig. 50 A).

When the natatory ligaments were involved the fingers could not be separated freely.

Generally flexion appeared first in the metacarpophalangeal joints and later in the proximal interphalangeal joints. The highest degree of flexion deformity then usually developed in the latter. The distal interphalangeal joints were also sometimes flexed but in some cases they were hyperextended. This was probably due to the action of the intrinsic muscles of the hand. In seven patients the disease started in the digital prolongations of the palmar aponeurosis and the deformity was then at first more pronounced in the interphalangeal joints (Fig. 48 A).

The contraction of the fingers varied in degree and the condition could remain stationary for many years at any stage. In the most severe cases the fingers flexed until the tips came close to the palm, the hand thus presenting a very characteristic deformity. A classification of the degree of deformity is given on page 159, according to

which the patients presented here are grouped in Table 11, p. 161.

Although the distribution in small series is of little significance, the following data are given for the sake of completeness.

The condition was bilateral in 35 cases out of 50. Of these 35 patients the involvement of the right hand preceded that of the left in 19 cases, the left preceded that of the right in 12 cases, and in 4 cases it was stated that both became affected simultaneously. The longest interval between involvement of the two hands was 33 years and the average interval 4.5 years. In unilateral cases the longest duration of the disease was 20 years and the average duration 6.5 years. In cases of bilateral contraction the hand first involved was invariably in the more advanced stage of the two. The relative frequency with which the various fingers were involved is shown in Table 5. The 11 hands with thumbs involved include several cases with nodules only at the base of the thumb and others with involvement of the thumb web. This might explain the comparatively high incidence of thumbs affected in the present series. In none of the cases was the function of the thumb limited to any noticeable degree and at this site the early stages of the condition might easily be overlooked. That the thumb is most rarely involved is in accordance with the anatomical fact that an extension of the palmar aponeurosis to the thumb is lacking in the majority of hands.

Most patients stated that the progress was slow and continuous. The few exceptions from this rule are reported on page 127. The average duration of the disease for all cases was 7.7 years, varying from three months to 33 years.

Subjective Symptoms. As previously mentioned, the nodules appearing in the palmar aponeurosis may at first be slightly tender. One of the patients sometimes felt dull aching in the palm, specially in the mornings. One reported prickling in the flexed finger, another an abnormal tingling, burning sensation in the affected area. Some cases described a pulling sensation in the palm towards the contracting fingers when the disease was in an active stage. During the development of finger contraction the patients never complained of pain, but any attempt at extension produced pain in the line of the retracted band.

Some of the patients engaged in heavy manual work stated that their hands often developed sores and when their contracted fingers were accidentally caught, partial rupture of the band as well as of the indurated skin sometimes occurred, resulting in transverse open wounds. A physician found great difficulty in percussion. A surgeon complained of severe irradiating pains in the affected fingers when the projecting surfaces of the palm were exposed to pressure. This hindered him considerably in his work as he could not, for instance, use heavy forceps in operating. A woman found difficulty in spreading flour over the board when making pastry. In other cases the deformity had made piano-playing impossible, etc.

CHAPTER III

Pathology and Pathogenesis

I. PATHOLOGY

1. Survey of the Literature

Plater (1614) interpreted the cords in the palm of the hand as flexor tendons. This opinion was still held as late as the beginning of the 19th century, when the condition was called *crispatura tendinum.*

In 1822 Cooper stated that the deformity was produced by contraction of the palmar fascia. Dupuytren (1832) however, appears to be the first surgeon to investigate the condition by dissection and to reveal its true localization. He gave the following description of one case: "Exposing the palmar fascia I was astonished to perceive that this fascia was tense, retracted and shortened. From its lower portion were given off kinds of cords, which passed to the diseased fingers . . . I cut through the prolongations extending from the fascia to the fingers; the state of contraction immediately ceased . . . I examined the tendons with care. Their surfaces were smooth and they enjoyed their usual degree of motion; the joints also were in a healthy state . . ." Several workers were later able to verify Dupuytren's classical observations and it is only correct that his name should be associated with the disease.

Despite its indisputable nature, this discovery was not accepted for some time. Alibert (1832), for example, described the condition as a skin disease, *Paratrimma palmare.* The fact that in advanced stages the palmar skin loses its normal characteristics and becomes intimately connected with the aponeurosis caused a number of writers to believe that the primary seat of the disease was in the skin (Cruveilhier 1849, Baum 1878, and others). As late as 1886, Amat regarded the changes in the aponeurosis as secondary to the dermatitis which he believed was present.

Goyrand (1833) was also unwilling to acknowledge the decisive importance of Dupuytren's discovery. On the basis of a dissection of a case of this kind, he stated that the palmar aponeurosis was entirely normal and that the flexion of the fingers was due to a new formation of abnormal subcutaneous fibrous fasciculi. A number of other workers shared his opinion (Fergusson 1846, Malgaigne 1862, Eulenburg 1863, and others). As late as in 1917 Hutchinson found it difficult to explain why the proximal interphalangeal joints should be the most affected by the contraction, since it is generally assumed that there are no fibrous bands going to the fingers, which by their shortening could possibly produce flexion of those joints. He therefore asserted that the disease "does not limit itself to the normal anatomical bands, but that fresh fibrous prolongations are developed."

All these often heated and polemic discussions can now be considered as beside the point. They paid no attention to the vastly more important question of why and how these bands were formed. The description of the anatomy of the palmar aponeurosis in Chapter I of the present study shows that it is not necessary to assume the formation of fresh fibrous bands outside the aponeurosis in order to explain the clinical picture. The deep extensions of the aponeurosis are attached to the sides of the proximal phalanges and extend to the bases of the second phalanges and in addition the pretendinous bands continue onto the fingers. The effect of these bands when they undergo hypertrophy and retract is demonstrated in a dissected specimen (Fig. 14).

It is natural that if the fingers, as a result of changes in the aponeurosis, are kept for a long time permanently flexed, *secondary changes* occur gradually in the joints involved as well as in the other tissues of the fingers. It was demonstrated, for example, on dissection preparations that in cases of long standing when all the structures were removed with the exception of the ligaments, the fingers could not even then be extended freely (Reid 1836, Fergusson 1846, and others). It has also been shown that the surfaces of the joints are changed and the joint cartilages show degeneration (Richer 1877, Lane 1885, and others). In addition, Eulenburg (1864) observed hyperostotic formations on the dorsal aspects of the flexed middle phalanges.

Fig. 14. Nodular aponeurotic band causing flexion deformity of the little finger. Dissected specimen in the Museum of King's College (after Adams, 1878).

Pathohistology

The first descriptions of the microscopic pictures of the disease were based on single observations. More experience of larger material does not, however, appear to have increased our knowledge of these tissue changes to any great extent.

Richer (1877) observed that the fibrous tendon-like bundles were more compact and more numerous in the retracted bands and that the subcutaneous tissues were indurated in the parts adherent to the skin, but the skin itself was normal.

Durel (1888) reported an observation made by Doyen concerning the appearance of small nodules in the aponeurosis in this disease and called them "véritables fibromes." Langhans (1887) was, however, the first to give an accurate microscopical description of these diffuse cellular areas of connective tissue which are so characteristic of Dupuytren's contraction, and considered that a process of proliferation without true inflammatory phenomena was present. He found an increase of cells in the nighbouring areas of the aponeurosis, specially in the adventitia of the adjacent vessels.

Janssen (1902) mentioned the presence of blood pigment in the aponeurosis. This was regarded as remains of haemorrhages caused by injury in operation. He categorically denied a traumatic origin of the disease.

Anderson (1897) described the condition as inflammatory hyperplasia or neoplastic growth commencing in the skin, and McWilliams (1904) regarded it as chronic hyperplastic inflammation with subsequent formation of scar tissue.

Iklé (1928), as did Janssen (1902), described the cellular areas as sarcoma-like but pointed out at the same time that there was no question of infiltrative growth or metastasis, and the area was also too diffuse to be considered as a fibroma.

No essentially new observations or opinions are to be found in the works of Tarnowski (1887), Schmidt (1889), Merker (1897), Walter (1920), Kanavel et al. (1929), amongst others, and therefore only the most important investigations of recent date will be mentioned briefly.

Meyerding et al. (1941) studied the microscopical sections of the palmar aponeurosis in 57 cases of Dupuytren's contraction. They specially stressed the signs of inflammation in the surrounding tissues and regarded the condition as not merely a disease of the palmar aponeurosis but a disease probably beginning in the interstitial connective tissue and usually spreading to involve all structures from the skin down to the tendon sheaths. They classified the pathological picture as a chronic inflammatory process. They also assumed that the cellular nature of the fascia indicated the activity of the proliferative process and stated that no definite correlation was found between the degree of contraction and the grade of maturity.

With the wide variation in histological characteristics within the same specimen in this disease it is hardly possible, without serial sections, to make a satisfactory classification in the way described by Meyerding et al. It is therefore difficult to accept the theory they brought forward, i. e. that in cases in which histological examination reveals a low grade of maturity of the pathological tissue, recurrence is more likely to occur than in those in which higher grades of maturity are found.

Horwitz (1942) compared the microscopical anatomy of the normal palmar aponeurosis in 27 specimens from human cadavers to the histological features in Dupuytren's contraction in 35 cases. He found the essentials of the disease to be a "benign fibroplasia of the palmar connective tissues". He also pointed out the striking resemblance of the fibroplastic process to those of other localized fibroplasias such as keloids and fascial desmoids, as did

Clay (1944). In a study of tissues removed from 22 hands with Dupuytren's contraction, Clay came to the conclusion that the disease was due to a neoplasm — a cellular fibroma of the palmar fascia.

Finally, it must be mentioned that Krogius (1921), Deckner (1938), and others, believed the new formation of connective tissue to originate in embryonic remains of a superficial layer of primitive muscles of the palm. Schaumann (1944) based an aetiological theory on the histological conformity of Lupus erythematosus and the aponeurotic process. These hypotheses will be referred to in Chapter VII.

2. The Writer's Observations

A. Macroscopical Changes

The material on which the present investigations were carried out consisted of a number of patients who were treated for the disease by aponeurosectomy, an operation which gives at the same time a material complete enough for a general survey of the pathological anatomy of the disease. From this material, the writer is convinced that the anatomical basis of Dupuytren's contraction lies within the palmar aponeurosis itself, that structure being defined as in Chapter I of the present work. Involvement of every part of this structure occurred from time to time.

The main characteristic of the condition was the formation of masses of firm, greyish-white fibrous tissue, which thickened the structure of the aponeurosis. The tissue masses could vary from small nodules to larger and more extensive indurated areas. These phenomena occurred especially in the distal part of the palm and at the bases of the fingers, originating in the longitudinal fasciculi, in the paratendinous septa, in the natatory ligaments and in the attachments of the aponeurosis to the skin. Though sometimes excessive, spreading beyond the limits of the aponeurosis in a manner reminiscent of a tumour, the process of tissue change never involved adjacent formed structures: tendon sheaths, lumbrical muscles, digital nerves or blood vessels. These structures always remained distinct though in intimate physical contact with areas of tissue change. The digital nerves in particular were at times considerably displaced as a result of the expanding process in the aponeurosis. Indeed, owing to the position and shape of the aponeurosis, these nerves were

often entirely surrounded by massive fibrous tissue. Even so, it was possible to dissect them clear. Superficially, they always appeared normal.

A second characteristic of the condition was pronounced retraction of the parts affected, causing flexion of the fingers. The thickening of the aponeurosis frequently took the form of cords, extended in an axial direction to each flexed finger. As described in the symptomatology, these cords were sometimes reminiscent of "bowstrings". They were never isolated in their course, but were always integrated with other fibrous masses. In a number of cases the cords were particularly well defined and up to approximately five mm in diameter. In transverse section they were tendon-like in appearance. Not infrequently the normal subcutaneous fat layer had disappeared over these cords and they were fibrously attached to the skin at these sites.

B. Pathohistology

Specimens of the palmar aponeurosis removed from 29 patients were examined microscopically. As comparative material the palmar aponeuroses from 10 post-mortem cases (5 men and 5 women) were examined.

In the opinion of the present writer, earlier workers in this field have given too little consideration to the structure of the diseased aponeurosis as a whole. This was seldom possible earlier, since it is only modern methods of operation, permitting complete aponeurosectomy, that have afforded the requisite material. Even with these methods it is seldom suitable from a technical point of view, to remove by complete excision the aponeurosis *en bloc*. Even in those few previous cases where this was done, only "typical" parts were apparently taken for microscopical examination.

In order to obtain a better survey of the localization of the disease and its extent, the present writer has, when operating, endeavoured to obtain the complete preparation for microscopical study. It is then easiest to examine the dominant, longitudinal fibre bundles. A longitudinal section is shown in Fig. 15, stained with a stale solution of Weigert's iron haematoxylin. With strong differentiation, the nodules in the aponeurosis, corresponding to richly cellular connective tissue, appeared light

Fig. 15. Longitudinal section through ulnar part of palmar aponeurosis in the plane of its palmar surface in a 45-year-old man with Dupuytren's contraction of 6 years standing. Stained with Weigert's iron haematoxylin (see footnote p. 45). (× 5.5.)

a — band to little finger; b — band to ring finger; c — natatory ligament between little and ring finger; d — hypercellular areas (cf. Fig. 17 A).

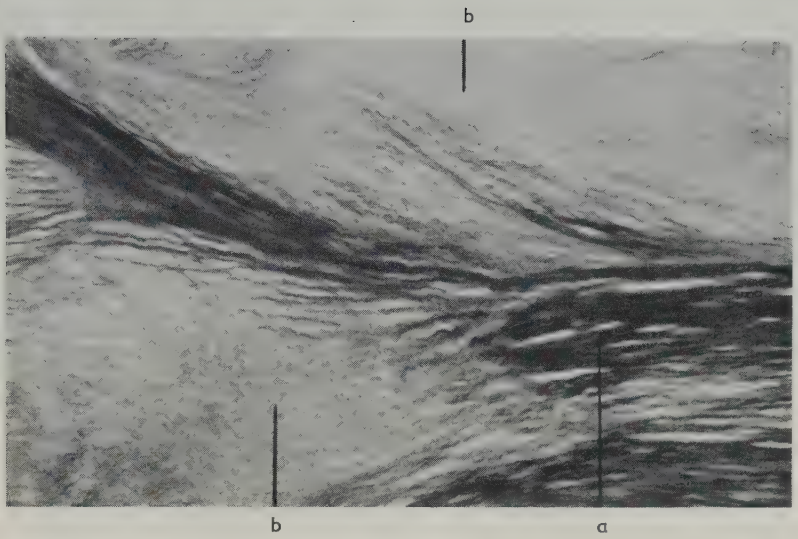


Fig. 16. Photomicrograph from the section shown in Fig. 15 at greater magnification (× 100).

Note how some bundles of collagen fibres (a), stained black, pass through the gray areas (b) (cellular tissue) whereas others show signs of interruption in the border zone of the cellular area.

in contrast with the poorly cellular fibrous tissue of the aponeurosis, which stained dark.[1] The figure shows how the cellular areas are distributed in the homogeneous fasciculi of the aponeurosis. Sections corresponding to the cellular areas and those poor in cells, stained with haematoxylin and eosin are shown in greater magnification in Figs. 17 A and B. These areas of hypercellular connective tissue occurred irregularly and in variable numbers in the pathological aponeurosis. They were diffusely defined towards the surrounding aponeurotic tissue and showed varying degrees of maturity. The areas shown in Fig. 15 are small and represent a relatively early stage with young connective tissue. Others at times were of such a size that they protruded in the form of nodules on the surface of the aponeurosis.

As was pointed out earlier, these nodules can clinically be regarded as the initial stage of the disease and the writer wishes, on the basis of his own investigations and the statements available in the literature.

[1] These staining conditions were observed by chance in trial staining with stale solution. The fibrous tissue does not stand out as distinctly when newly mixed Weigert's iron haematoxylin is used.

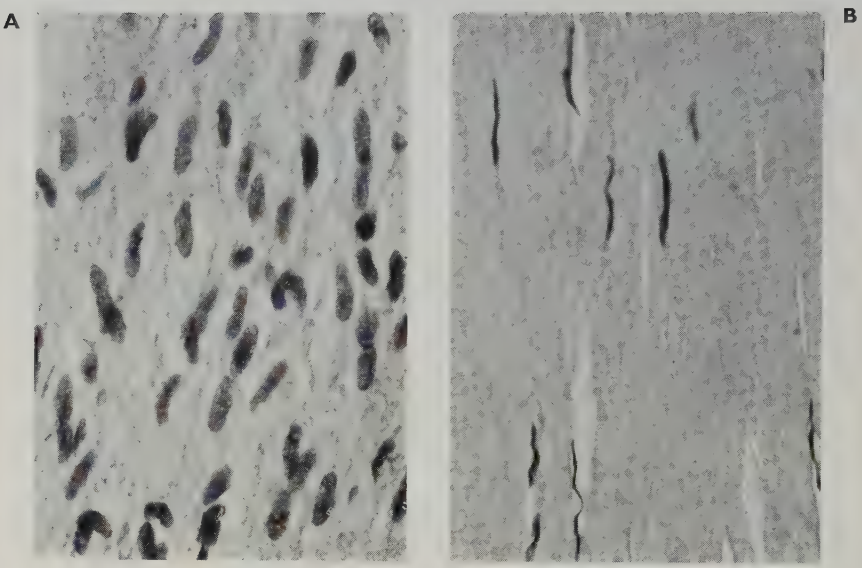


Fig. 17. **A** — Section corresponding to the gray areas in Fig. 15 (d) and Fig. 16 (b) showing undifferentiated connective tissue. Such localized hypercellular areas substantiate the nodular thickening of the palmar aponeurosis characterizing Dupuytren's contraction.

B — Section corresponding to the aponeurotic bands stained black in Fig. 15 (a, b) showing tendon-like poorly cellular connective tissue almost entirely composed of compact bundles of collagen fibres. The nuclei are thin and elongated. A and B stained with haematoxylin-eosin. (× 500.)

to consider these hypercellular areas as pathognomonic for the pathohistology of the disease. It is therefore surprising that their morphogenesis has been so little studied. The question has been the subject of particular attention by the writer and the observations made will be given here.

It appears to the writer that even the general picture in Fig. 15 gives the impression that there is an interruption in the fasciculi of the aponeurosis at these sites. If the borderline of such a light cellular area is examined at a higher magnification (Fig. 16) it is seen that the fibre bundles of the aponeurosis are partly split by the expansile proliferating connective tissue, but that a number of fibres also unmistakably show signs of interruption in this region. In the same figure it is seen, for example, how a number of fibres look frayed and have the wavy structure characteristic of ruptures of collagen fibres. It was only in areas whose structures indicated

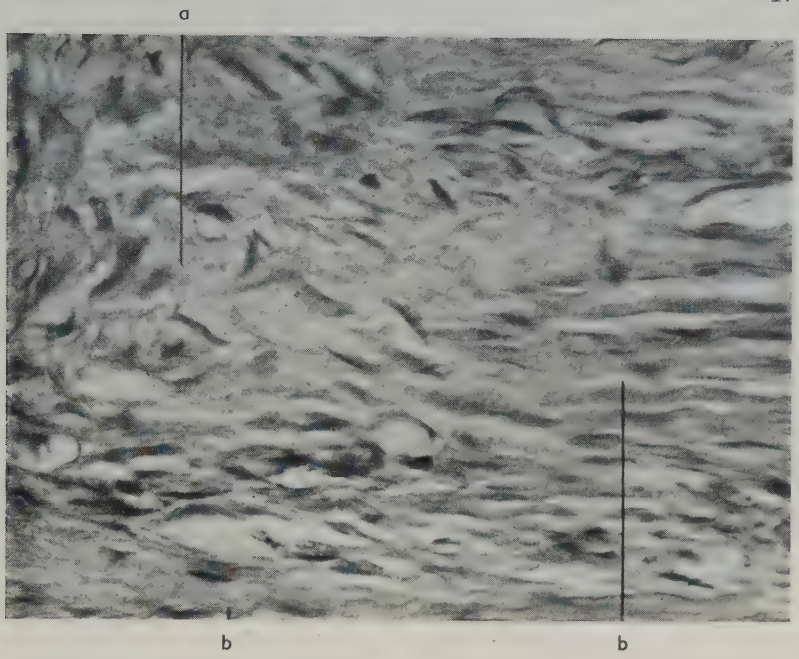


Fig. 18. Section from the palmar aponeurosis in Dupuytren's contraction, showing the periphery of a cellular area of young fibroblasts (a). Note how a number of the collagen fibre bundles (b) in the aponeurotic tissue show signs of interruption in the border zone of the cellular area. Stained with haematoxylin-eosin. (× 470.)

that they were relatively new in which such distinct interruptions in the aponeurotic tissue could be observed. In other areas the fibrillar elements of the aponeurosis merged more organically with the intercellular substance. In a number of places the border was relatively distinct, with a zone of connective tissue cells towards the aponeurotic tissue.

A very early stage in the development of these nodules is shown in Fig. 18 with young undifferentiated connective tissue. In a number of sections it was possible to observe how these new formations of connective tissue issued from the perivascular tissue of the adjacent vessels. The vessels in the vicinity were dilated and increased in number and were surrounded by perivascular sheaths consisting of fibroblasts as well as a few leucocytes and round cells (Fig. 19) and at times even a few mast cells. The round cell elements predominated beside more mature areas. It was certainly not a question of an inflammatory tissue reaction.

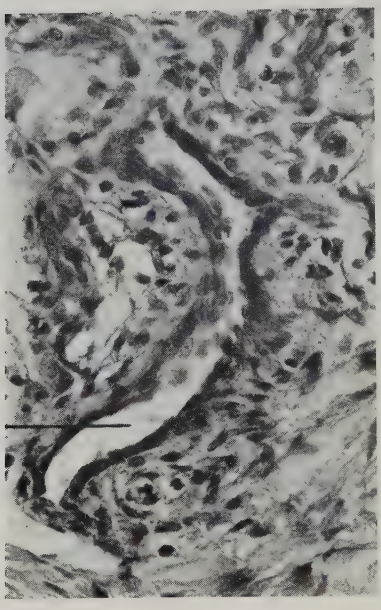


Fig. 19. Photomicrograph showing blood vessel (a) with perivascular cellular tissue mainly consisting of fibroblasts. Section taken from the periphery of a cellular area in Dupuytren's contraction similar to that seen in Fig. 17 A. Stained with haematoxylin-eosin. (× 370.)

Figs. 20 A—D show the development of the cellular areas from a relatively early stage of undifferentiated connective tissue to a fibrous tissue. In the earlier stages there were mitotic figures but the growth was uniform and regular. The intercellular fibres were very thin and stained brownish-black on silver impregnation (Bielschowsky's method) indicating that they were precollagen in character. In later stages these fibres stained in a manner typical of collagen substances. There appeared to be no new formation of elastic fibres. In the smaller nodules the intercellular substance and the cell nuclei showed a relatively regular arrangement parallel to the surrounding fibre bundles. In cases in which the nodules had extended beyond the true aponeurosis, their transverse section gave a confused impression, with the general direction of the cells in various parts traversing each other in several planes. Moreover, the degree of maturity in the various parts of these large nodules varied at times. It was not possible to establish any relation between the histological picture and the clinical features of the disease. It is particularly interesting that the cellular areas in the central parts contained iron pigment

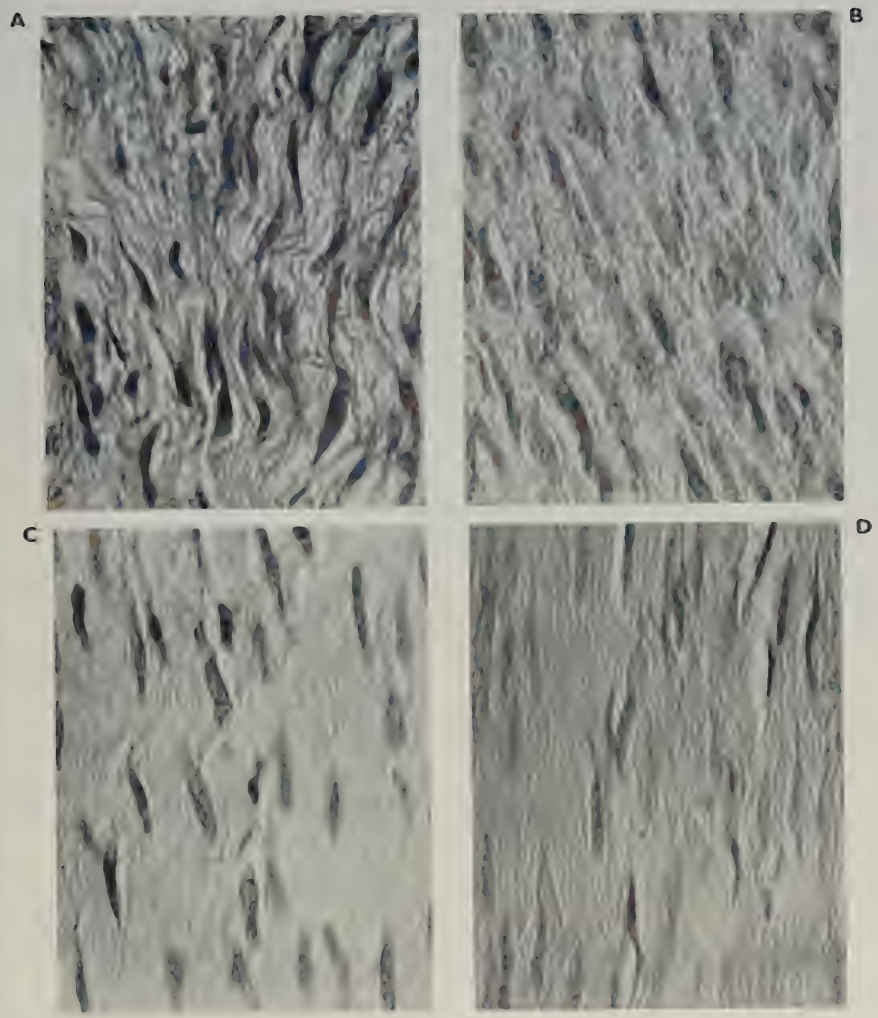


Fig. 20. Sections showing various stages of maturity in the cellular areas of the palmar aponeurosis in Dupuytren's contraction. Stained with haematoxylin-eosin. (× 500.)

A — early stage in which mitotic figures occur. Plentiful young connective tissue cells, appearing to form a syncytium. The tissue is basophil. **B** — The cells are more regularly directed then in the earlier stage. The nuclei are oval, relatively large, and stain rather poorly. The intercellular substance is basophil. **C** — Shows a greater degree of maturity than B. The cells are more markedly spindle-shaped and the nuclei stain more strongly. There is an increase of intercellular substance. **D** — Shows scar-like fibrous tissue. The intercellular substance is markedly acidophil and there are numerous collagen fibres. Even at this stage the tissue is fairly cellular.

A certain irregularity in the general structure is seen on observation of larger areas than in these sections.

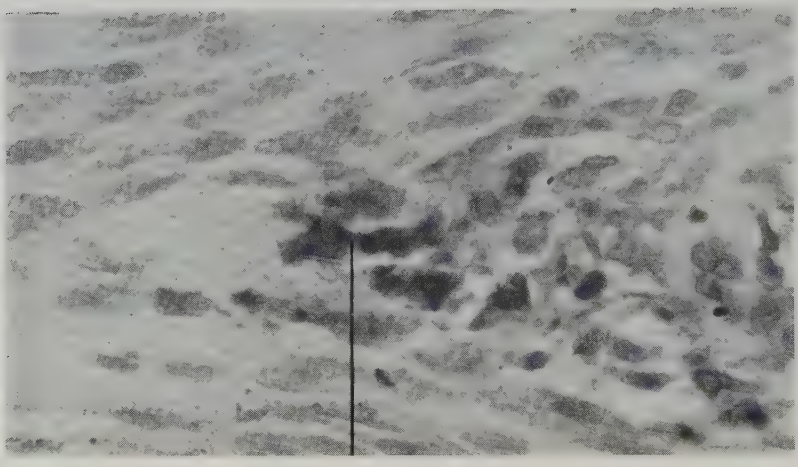


Fig. 21. Section from the centre of a fairly fresh nodule of the palmar aponeurosis in Dupuytren's contraction. The dark staining of the tissue at (a) is due to plentiful iron pigment in the cells and in parts of the intercellular substance. Stained Berlin blue. (× 500.)

(Fig. 21). This was most abundant in the younger areas. Iron pigment did not occur in the normal parts of the aponeurosis nor in the normal material.

The pathological tissue was also characterized by the tendon-like cords described earlier. These consisted of compact, fibrous connective tissue on the whole reminiscent of normal aponeurotic tissue. The relative cellularity was, however, smaller owing to a considerable increase of the intercellular substance. In particular the collagen fibres were coarser and more numerous whereas the elastic fibres only appeared in small numbers even on staining differentially for elastin. Histochemically, this connective tissue differed from the aponeurotic tissue of normal appearance in that it was less acidophil and stained yellowish-brown with van Gieson's method instead of a reddish colour as did the normal aponeurosis. Staining with azan gave a red colour in large areas of the otherwise blue tissue, when it could have been expected that the entire cord would have been homogeneously blue. Such deviations from the normal stainability were only exceptionally found in small areas in the normal aponeurotic tissue.

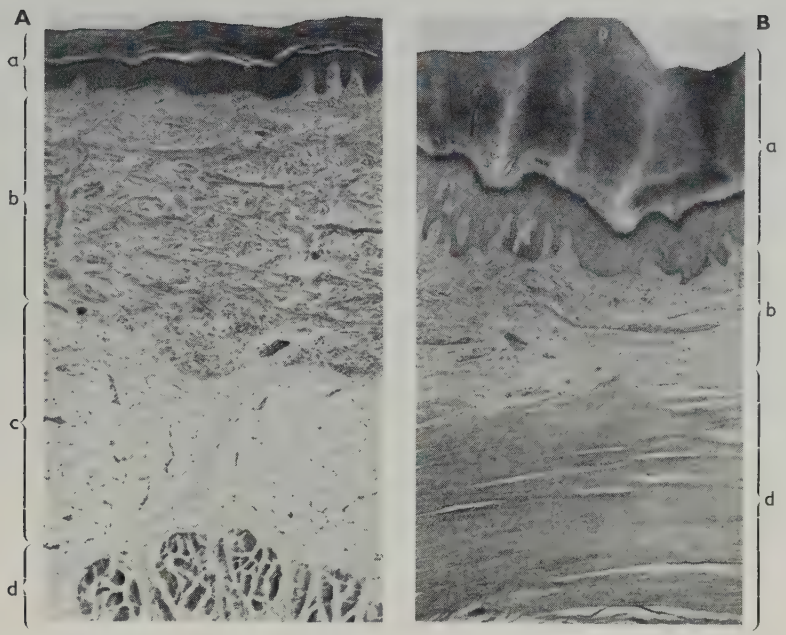


Fig. 22. Sections through the palmar skin and aponeurosis. **A** — in normal conditions; **B** — in Dupuytren's contraction Photomicrographs. (× 20.)
a — epidermis; b — corium; c adipose tissue; d — palmar aponeurosis.

Note in B thickening of the aponeurosis and epidermis as well as disappearance of the subcutaneous adipose layer.

Staining with toluidine blue[1] gave, within the cords, a very pronounced diffuse metachromasia. This was not the case in the rest of the aponeurotic tissue. This was a true metachromasia, i. e. it remained unchanged after heating and was not affected by absolute alcohol.

None of these unusual staining reactions can be regarded as the expression of any known pathological condition of the connective tissue.

Skin. In the operating technique used in the writer's material, the palmar skin was not excised. Only in seven cases were small portions removed for microscopical examination from areas in which the skin

[1] The preparations were stained with toluidine blue (Grübler & Co., Leipzig; made for staining of mucus) in 0.5 per cent solution, followed by differentiation in 96 per cent alcohol. The preparations were mounted in Canada balsam via absolute alcohol and toluol.

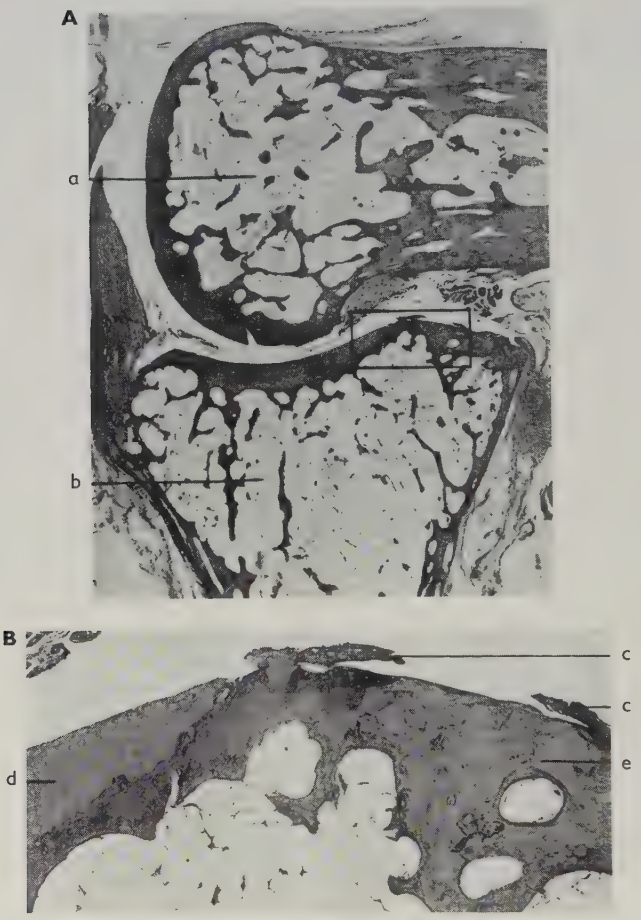


Fig. 23. Sections of the 5th proximal interphalangeal joint in a 74-year-old woman with Dupuytren's contraction of about ten years standing. B corresponding to square in A. Stained with haematoxylin-eosin. Photomicrographs. (× 5 and × 25.)

a — proximal phalanx; b — middle phalanx; c — fragment of cartilage; d — normal articular cartilage; e — bone.

Note deformity of the articular surface of the middle phalanx. Its volar third, which is not in contact with the articular head, lacks cartilage except for a few small fragments (c).

appeared to be affected by the changes in the underlying aponeurosis. In three cases there was slight hypertrophy of the epidermis in these areas, caused by thickening of the horny layer. In the papillary zone there was some irregularity. The corium was fibrosed, and in the

subcutaneous layer the normal, adipose tissue was replaced by dense fibrous tissue which attached the skin tightly to the aponeurosis. Fig. 22 shows some of these findings.

Finger-joints. The flexion deformity is usually most pronounced in the proximal interphalangeal joints. In one case the writer was able to examine microscopically one of these joints in which permanent flexion had caused subluxation of the second phalanx and owing to the great age of the patient amputation was decided on. The sections in Fig. 23 show the deformity of the joints. This was most apparent in the shape of the concavity of the second phalanx. It is interesting to note that the cartilage of this articular surface had only disappeared in that region which was not in contact with the opposite articular surface. On the articular head the entire cartilage was present although it showed signs of degeneration in small areas. In life, however, pressure and friction from the articular concavity as well as from the joint capsule on the dorsal aspect is exerted on the whole surface of the head. These functional factors are naturally of decisive importance for the retention of the cartilage. This preparation also showed that the joint capsule on the volar aspect had shrunk to a tense thickened connexion in the angle between the two phalanges.

No microscopical examinations of this kind are to be found in earlier works on Dupuytren's contraction.

These joint changes cannot be considered as specific to the disease. They can be satisfactorily explained as an effect of a faulty position of long duration and of abnormal pressure on the articular surfaces. From a practical point of view these secondary changes are of very great significance. If the cords which originally gave rise to the flexion are removed, it is surprising to find that the changes are reversible to a great extent with rational after-treatment (Fig. 48).

C. Electron Microscope Observations

The electron microscope technique provides a promising method for studying the fibrillar structures of collagen tissue. Micrographs made with the electron microscope have revealed that the finest collagen fibres which can be resolved by the light microscope are formed by submicroscopic fibrils. Schmitt et al. (1942) for instance, found that in the preparations of collagen tissue from various species,

certain widths, of the order of 500—1,000 Å, greatly predominate. These authorities also thought that this implied that such units might exist in the intact tissues. Many collagen fibrils are characteristically cross-striated due to a regular alternation of relatively dense and transparent bands. SCHMITT et al. found the periodicity of this "spacing" as revealed by the electron microscope to vary considerably from one fibril to the next but the average value, 644 Å, coincided with the X-ray fibre-axis long spacing of 640 Å reported by BEAR (1942). These findings are interesting but further investigations are required before the relation of electron microscope observations to physical chemical data previously obtained can be estimated.

In the application of the electron microscope to biological investigations, there are as yet many unresolved sources of error. Provided, however, that its application is restricted to comparative investigations under strictly uniform conditions, the electron microscope can provide valuable information as to the submicroscopical structure of tissues. In this particular investigation, it has been applied to material collected from the diseased and normal parts of the palmar aponeurosis in patients suffering from Dupuytren's contraction. As far as the writer is aware, investigations such as are reported here, using this instrument, have not previously been carried out.

Material and Methods. In nine operated cases of Dupuytren's contraction, pieces a few millimetres in length were excised from the characteristic, tendon-like cords which extend within the aponeurosis towards the contracted fingers. The sections were taken at sites where the cords were well defined and with a completely homogeneous tendon-like appearance on the surface of the section. They were excised as proximally as possible in the palm, i. e. within a part of the aponeurosis where cellular areas were rarely observed. As described earlier, these cords are chiefly composed of collagen fibres.

The control material consisted of six preparations from the aponeurosis of the same persons, but taken from parts in which it was of normal appearance and without signs of shrinkage.

Immediately after the excision the preparations were transferred to 1 per cent osmic acid (OsO_4) and fixed for at least a week. They were then washed in running water and sectioned by the freezing method.

The sections were immersed in a few cc distilled water in a 50 cc retort with a plane bottom and placed in an ultrasonic field for 150 seconds. In addition, fractions of seven specimens were exposed to ultra-sound for 60 seconds only. A magnetostriction oscillator with a frequency of 22.7 kilocycles and an effect of 0.3 watt/cm^2 was used. The vibrations produced by the ultrasonic field exhibit strong dispersive powers. This has proved eminently suitable for converting collagen fibres into submicroscopic fibrils.

A drop of this water suspension of the specimen was placed on a conventional electron microscope specimen screen with supporting film. Electron micrographs from five different parts of the visual field of each preparation were taken at a magnification of 20,000 times with a Siemen's electron microscope. Extremely hard paper was used for the photographic prints. The width of all the fibrils below 500 Å was measured on the prints with an ocular micrometer at a magnification of 16 times. At the narrowest part of each fibril three measurements were taken and the average was used. Thick fibrils were excluded since in many cases they were in all probability composed of a number of finer fibrils. Fibrils showing definite cross-striation were measured under a magnifying lens for as long a distance as possible and the average figure of the "spacing" was calculated. In order to obtain the maximum of objectivity the fibrils were measured without advance knowledge of the group of material to which the micrograph belonged.

The method was used earlier by Ingelmark (1948) on tendinous tissue. He discussed the sources of error of the method and made a partial study of them. In this connexion one of his observations is of interest, i. e. that neither the duration of the ultra-sound treatment (30, 90 and 100 secs.) nor the ultra-sound frequency (22.7 and 300 kilocycles) affected the width of the fibrils. The reader is referred to his paper for further details.

Results. Fig. 24 shows an electron micrograph of palmar aponeurotic tissue. The width of the fine fibrils ranged from 140 to 460 Å. Larger fibrils often branched and thus appeared to be bundles of thinner fibrils. The cleavage was always longitudinal. Moreover, when there was a break in a large fibril some of its finer fibrils were seen to continue their course without interruption.

In order to obtain sufficient material for statistical treatment, and to ensure that the extremely small preparations examined were representative, all the fibrils measured in each group were collected and their average width (M) calculated. The result (Table 6) shows

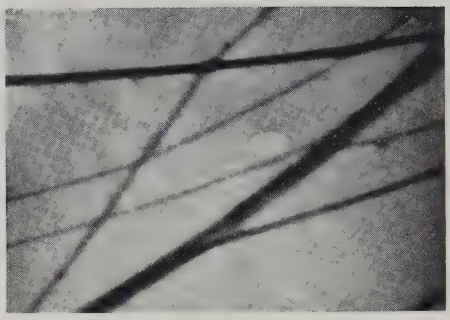


Fig. 24. Electron micrograph showing collagen fibrils from normal palmar aponeurosis. The finest fibrils cross-striated about 300 Å in width. Note branching of thicker fibril. (× 20,000.) (Cross-striation clearer in original micrograph.)

that the width of the fibrils is greater in the dense fibrous cords in the pathological parts of the aponeurosis than in the normal aponeurotic tissue. The difference, 27 ± 3.8 Å (approximately 10 per cent) is statistically significant. The fractions of the preparations which were only treated with ultra-sound for 60 seconds are also included in these figures since this deviation in the method does not affect the width of the fibrils. The widths of the fibrils in both groups are shown graphically in Fig. 25.

The characteristic striated structure only appeared clearly in the fine fibrils. The distance in the direction of the long axis between adjoining bands of similar photographic density — the spacing — was fairly uniform in any given fibril but varied between 350 and 750 Å approximately in different fibrils. The average figure was found to be lower in the preparations from pathological tissue (Table 6). Owing to the infrequency of clearly striated fibrils (as shown in

TABLE 6

Electron Microscope Observations on Collagen Fibrils from the Palmar Aponeurosis in Dupuytren's Contraction (The Writer's Material)

	Normal tissue (N)		Pathological tissue (P)*		Difference
	Number	$M \pm \varepsilon(M)$	Number	$M \pm \varepsilon(M)$	$N—P$
Width in Å.....	291	256 ± 3.0	492	283 ± 2.4	27 ± 3.8
Spacing in Å	73	488 ± 9.5	65	465 ± 7.8	23 ± 12.3
Percentage frequency of striated fibrils.....	—	25 ± 2.5	—	13 ± 1.5	12 ± 2.9

* Selected parts of well-defined cords in the diseased aponeurosis.

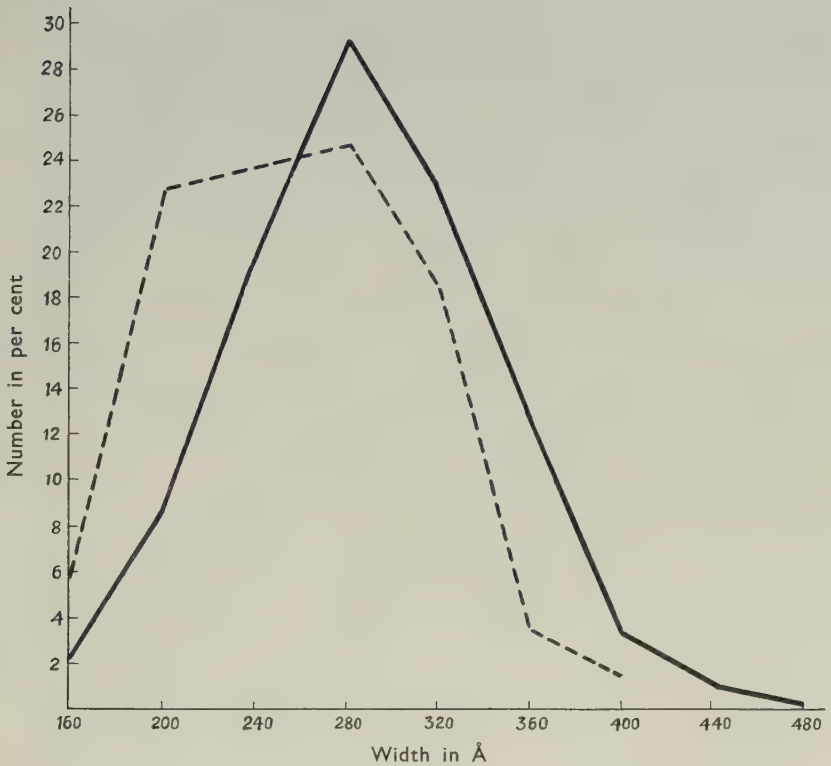


Fig. 25. Distribution of widths in the collagen fibrils given in Table 6. Note how, in comparison with the curve representing normal aponeurotic tissue (dotted line) that for the pathological tissue (unbroken line) is displaced in the direction of greater widths.

the same Table) the difference in spacing between the normal and pathological tissue is subjected to such large average errors that it is not possible to determine whether this is merely accidental.

Cross-striated fibrils, partly split into finer fibrils with identical striation, are at times seen on the electron micrographs. Since it is not possible to determine the frequency of such bundles in the striated fibrils measured in the respective groups, a comparison of the relation between the width of the fibrils and the spacing would give very indefinite information.

Discussion. It is of interest to note that in principle the collagen fibrils showed, with small deviations, the same structure in the normal and pathological parts of the aponeurosis, and also that these

observations agree on the whole with those made previously as regards collagen fibrils in general. The width of the fibrils was, however, throughout less than that generally stated. Shrinkage of the preparation through lengthy fixation may possibly have been a contributory cause. In this connexion it is to be noted that INGELMARK obtained somewhat higher figures for the width of collagen fibrils from tendon tissue, using the same method but with fixation for 24 hours only. The absolute figure for the width of the fibril is, however, of less importance in the present investigation. Even if collagen tissue is well able to withstand the considerable physical effects of various kinds in the electron microscope method, it is impossible to determine accurately to what extent the structures observed correspond to conditions in vivo.

It is also possible that, using an improved technique, the collagen fibrils studied here could be split into still finer morphological units. Using ultrasonic waves for dispersion, however, the fibrils are distinguished as a relatively uniform group with an average width comparable to that obtained for the collagen fibrils with another technique in preparing the specimens. The figures in Table 6 can only be afforded a relative value. Nevertheless, the statistically significant difference in the average width between the pathological and the normal tissue is still of interest, despite this limitation, since both materials were similarly treated. The significance of this fact will be considered in the section on pathogenesis.

If the regular cross-striation of the fibrils corresponds in any way to the arrangement of the long polypeptide chains which form these fibrils, it is of interest that a difference in the spacing of the two groups examined exists, even though this is not statistically significant. The pathological tissue with an average value of spacing below that of normal aponeurotic tissue represents in fact a retracted collagen tissue. On the basis of other investigations there is reason to believe that the shortening of collagen fibrils is caused by a change in the configuration of their polypeptide chain system (ASTBURY 1941, and others). Variations of the periodicity from one fibril to another within the same specimen would then imply a varying condition of retraction in the fibres. As has been mentioned previously, the method of examination can, however, have affected their structure in some unknown manner.

The importance of the statistically significant difference in the frequency of striated fibrils in the respective groups is uncertain. Wolpers (1944) mentioned that cross-striation in collagen fibrils was lacking in a number of pathological conditions (myxoma, etc.). He did not give any explanation of this remarkable statement. As regards the present writer's material, it would appear probable that the histochemical peculiarities in the aponeurotic tissues manifested in staining with various media could in some way be connected with the various submicroscopical characteristics of the fibrils.

II. PATHOGENESIS

In the account given above of the pathological anatomy of the disease, it was described how the characteristic changed areas in the aponeurosis develop from a stage of young, richly cellular connective tissue into more or less scar-like tissue. This development appears to the writer to indicate that these local tissue changes arise on the basis of partial ruptures in the aponeurotic tissue. The extent of the pathological areas would in this case imply multiple ruptures and it is questionable whether a plausible trauma could in fact have such an effect.

In order to ascertain whether this was the case, the writer overstretched the longitudinal fibres of the aponeurosis by hyperextending the fingers. This was done in a few cases immediately before operation. Microscopical examination of these preparations verified the assumptions made. Partial ruptures, of varying size and irregular distribution, were present in the longitudinal fasciculi of the aponeurosis. Figs. 26 A and B show two such experimentally produced ruptures. If Fig. 26 B is compared with Fig. 18, which shows the border zone of a cellular area within the aponeurosis, the similarity in the fibrillar structure of the aponeurosis (b) in both pictures is striking.

The presence of iron pigment only in the newly formed connective tissue can be considered as strong support for this theory. Such pigment was found particularly in the centre of young hypercellular areas and can with all probability be interpreted as remains of small haemorrhages following local lesions in the aponeurosis.

The evident correlation of the disease to increasing age would

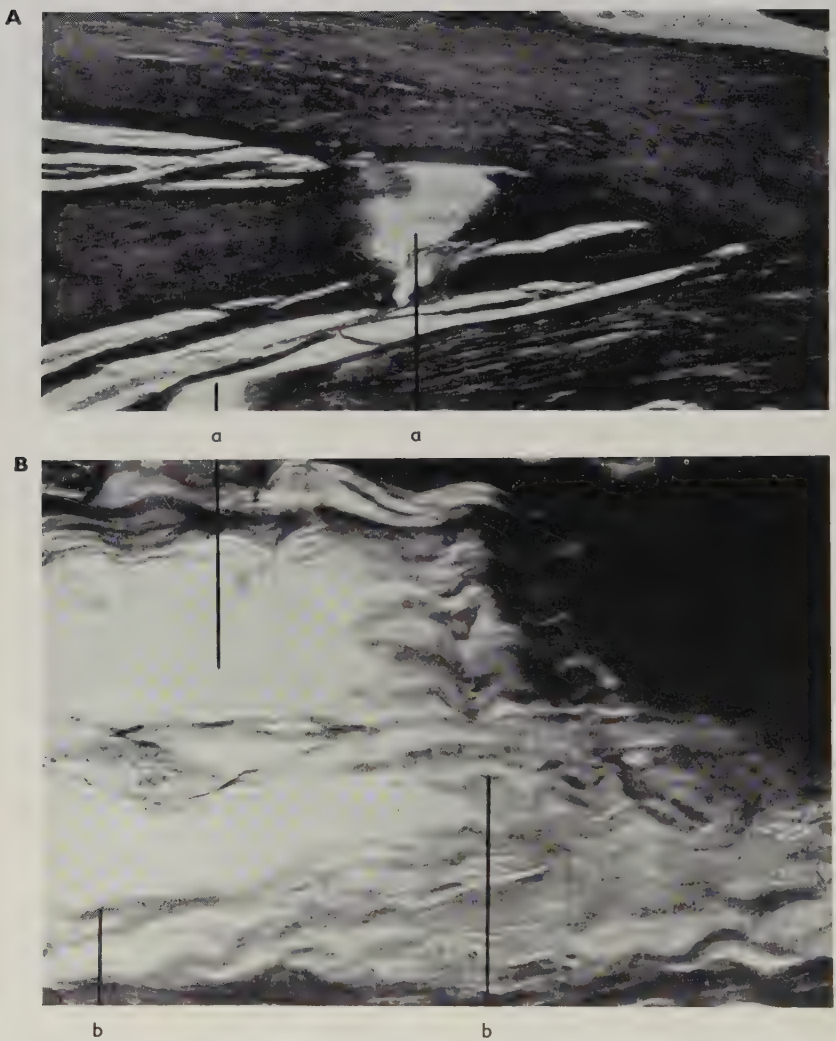


Fig. 26. Sections showing experimentally caused partial ruptures (a) of the palmar aponeurosis. For details see text. Stained with Weigert's iron haematoxylin.

A — (× 40) Note how some unbroken fibres pass through the main rupture;
B — (× 450) Note the wavy, frayed structure of the ruptured collagen fibre bundles (b).

be naturally explained in the light of the suggested pathogenesis since it is known that connective tissue undergoes changes in the course of years and, amongst other things, decreases in elasticity

and in stretching and breaking capacity (Payr 1921, and others). Increased age, accompanied by these changes, thus increases the possibility of ruptures of the connective tissue.

The question then arises: *Is such a pathogenetic theory sufficient to explain the entire pathological process in the peculiar form found at the fully-developed stage?* The course of development, as envisaged by the writer, is described below.

A partial rupture in the aponeurosis arises for some reason and this heals with connective tissue with plentiful cells which gradually, by means of an increasingly fibrillar substance, arrives at a scar-like stage. Here, as in all similar processes, shrinkage takes place. This gives rise to a tenseness in the fascicular system within which the process lies. A condition is then present from which there are several developmental possibilities.

If there is very little shrinkage and the connective tissue in the fasciculi is sufficiently elastic, the condition should remain stationary. If, however, there is considerable shrinkage or the fasciculi in the aponeurosis are brittle, the possibility of fresh ruptures is increased. A vicious circle then arises, which should lead to increased finger contraction if, for example, the strong pretendinous bands are involved. If shrinkage of an individual fascicular system occurs, this causes in addition a disturbance in the balance between the various fibrous systems of the aponeurosis, which can be accompanied by increased tension even in parts which are not directly involved. There is then the possibility of the process spreading to the adjacent parts in a similar manner. There is also a third possible developmental process, i. e. despite considerable shortening, the fasciculi have still such tensile strength that they do not rupture. When the hand is used to its full capacity, these retracted parts are exposed to greater functional strain than the other parts of the aponeurosis. It would then be only natural if, as a result, they underwent activity hypertrophy and became thickened.

The present writer's theory would thus also explain the development of the second characteristic of the pathological process, i. e. the massive cords of collagen connective tissue. These have a considerable tendency to shrinkage and their denseness causes unfavourable nutritional conditions in their central parts. In this way conditions for fresh ruptures would also gradually arise within these cords.

In actual fact, clinical analogies exist to the different developmental processes described above which thus can be thought to arise as a result of partial lesions in the palmar aponeurosis. Satisfactory comparative material is found in the description of the symptomatology of the disease in the writer's material.

Several reasons appear to support the above hypothesis regarding the development of the cords in the aponeurosis. The writer was able to observe that those patients in whom the cords of this type were thickest had been employed in heavy work or, by lengthy and energetic extension practice, had endeavoured to conquer the finger contraction. Patients who had paid no attention to the deformity showed considerably thinner cords. Such a finding is naturally subject to several sources of error but the phenomenon was so evident in a number of cases that it is worthy of mention. As pointed out previously, these tendinous cords only developed axially towards the fingers, thus entirely corresponding to the dominating direction of the forces, concerned in finger movement. Moreover, it is known that the cord-like thickening of the aponeurosis can disappear after simple subcutaneous division (Fisher 1885, Hohmann 1936, and others).

It is also interesting that these cords showed very marked metachromatic stainability, in contrast to the normal aponeurotic tissue. The significance of the metachromatic staining reaction is not yet elucidated but it is assumed to be usually caused by high molecular ester sulphuric acids. According to Krauss (1944), and others, it is characteristic of tissue in which new formation of the fibrillar substance of connective tissue takes place and also of tissues exposed to mechanical strain. An investigation made by Wrete (1947) also gives certain comparative factors for the writer's material. He found that diffuse chromotrope substances occurred regularly in the connective tissue of the valves and tendinous cords of the heart in man. It thus appeared at that site in dense, poorly cellular connective tissue, which is under considerable functional strain.

The electron microscope investigations previously described are also in good argreement with the theory postulated regarding the development of the cords. These results are very interesting when compared with those of Ingelmark (1946, 1948).

He was able to demonstrate experimentally on white rats that systematic training was accompanied by a statistically significant increase (11.2 per cent) in width of the osmium impregnated collagen fibrils in the tendons of Achilles. Moreover, these tendons were thickened throughout. This agreement with the electron microscope findings in the palmar aponeurosis in the writer's material is not surprising, on the basis of the theory regarding the pathogenesis of Dupuytren's contraction brought forward here. It should be noted that the electron microscope investigation reported by INGELMARK was carried out by exactly similar methods and with the same equipment and technical assistance as the writer's investigation. The comparative value is thus increased since the possible sources of error must have influenced the results of both investigations in a similar manner.

This pathogenetic theory also explains why surgical intervention consisting only of section of the retracted cords, without further measures, causes new masses of subcutaneous connective tissue to develop at the site of operation with resultant progression of the deformity.

It can also be mentioned that the writer in several cases found the plantar aponeurosis affected by the same pathological process as the palmar aponeurosis and in the foot the clinical symptoms definitely favoured a similar pathogenesis. (See Chapter IV.)

It is known from other fields that a physiological shrinkage of connective tissue can be as excessive as that found in advanced cases of Dupuytren's contraction. An example is the shrinkage of scars following deep burns of the flexor aspect of the extremities. With regard to these cords, it is also known that the more it is attempted to counteract them by means of extension therapy, the stronger they become. It has never been attempted to seek the explanation of this condition in a specific disease.

Finally, it should be emphasized that the newly formed fibrous tissue was regarded as scar tissue, more or less hypertrophic. In order to give a complete clinical picture of the writer's opinion regarding the pathogenesis, it must be mentioned that the mechanical irritation which can be assumed to exist during the healing process would contribute to the formation of excessive scar tissue. Individual factors are also of considerable importance. This question, as well

as predisposing conditions for the occurrence of lesions in the aponeurosis, will be discussed in the chapter on aetiology.

There was nothing in the writer's preparations to contradict the opinion that the *skin changes* described were secondary to the process in the aponeurosis. It would otherwise be impossible to explain why, after aponeurosectomy, the palmar skin regained its normal appearance and elasticity. Nor was there anything to contradict the fact that the moderate, diffuse increase of cells which occurred in the vicinity of the localized changes in the aponeurosis was a sequel of the latter process. Regarded as an unspecific tissue reaction around these areas, it was no more pronounced than that acompanying any other process of regeneration. Moreover, as a result of the clinical characteristics of the disease, the area affected is in many cases exposed to considerable mechanical irritation.

CHAPTER IV

"Dupuytren's Contraction" of the Plantar Aponeurosis

Closer investigation of the material reported here, consisting of patients suffering from Dupuytren's contraction in the hands, revealed that similar changes were present in the feet in several cases. Both with regard to its localization and to other symptoms, the nature of this disease when it occurs in the foot arouses particular interest in the anatomical structure of the plantar aponeurosis.

1. Anatomy and Embryology of the Plantar Aponeurosis

A. General Survey of the Anatomy

On the basis of comparative anthropological investigations, Loth (1908) differentiated between a lateral and a medial part of the plantar aponeurosis. The lateral part, also termed *aponeurosis plantaris fibularis*, is rudimentary in man. It is, however, of interest since phylogenetically it must be regarded as the primary structure. Its tarsal part occurs consistently and stretches from the os calcis to the tuberosity of the fifth metatarsal bone, whence the true fibular aponeurosis continues in the metatarsal region. It is lacking in 10 per cent of human beings.

Aponeurosis plantaris tibialis dominates and forms what is commonly referred to under the name of the ***plantar aponeurosis***. It arises as a strong fibrous band from the inner tubercle of the os calcis and consists of two layers; one superficial with extensions to the four lateral toes, and one deep layer running in a lateral-medial direction and partly appearing on the medial side as a separate band for the big toe. In contrast to the conditions in the hand, this extension occurs consistently. It is shorter and broader than the extension to the other toes.

In the metatarsal region the aponeurosis has become broader and

thinner and divides into five processes corresponding to the toes. A superficial insignificant part of these attaches to the skin and merges into the natatory ligaments and the fasciae of the toes. The main portion of each process divides into two slips, which embrace the flexor tendons of the toe, and are inserted into the sides of the metatarsal bones (Gray 1864). These series of arches, through which the tendons of the long and short flexors pass, correspond to the much thinner paratendinous septa of the hand. According to Braus (1929) their total transverse section is so large that it could support a load of approximately 150 kg. Each septum is about two mm thick and extends from the anterior edge of the transverse portion of the adductor hallucis muscle up to the level of the metatarsophalangeal joints. A number of fibres are crossed dorsally of the flexor tendons, and many of them merge into the accessory plantar ligament but no continuation onto the toes has been described.

In response to the special task of the sole of the foot, which is to bear the weight of the body and also to act as protection and support for the tissues in the foot, a subcutaneous tissue of a particular nature has developed in the supporting points corresponding to the os calcis and the anterior metatarsal region. In these regions the fatty tissue is prevented from being shifted towards the sides by the fact that it is enclosed in a fibrous network whose vertical fibres issue chiefly from the plantar aponeurosis and are tightly connected with the covering skin. In the hollow of the foot, these connexions are loose, so that the skin can be lifted in folds and the aponeurosis can be exposed by blunt dissection. (A detailed description of the finer structure of this tissue has been given by Benninghoff 1939.)

Two septa penetrate from the medial and lateral borders of the plantar aponeurosis deep into the sole of the foot, dividing the sole into three fibrous compartments. Testut and Jacob (1906) described how the medial septum in the posterior region allows passage to the long flexor tendons to the foot, and also how the tendon to the flexor hallucis longis once more penetrates this after its course along the lateral side of the septum. Henkel (1913) observed in addition a band from the central part of the medial region of the aponeurosis, directed distally and dorsally, and dividing into two slips. The lateral one partly inserted into the 3rd cuneiform and partly merged with the tendon of the flexor hallucis brevis muscle. The other slip (not shown

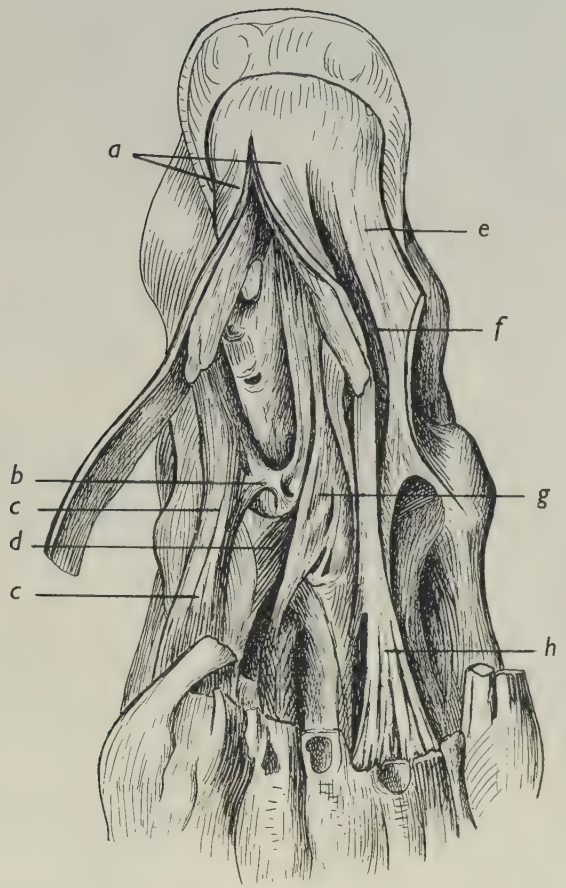


Fig. 27. Deep attachments of plantar aponeurosis (redrawn after HENKEL 1913). a — tibial portion of plantar aponeurosis; b — lateral branch of deep, vertical ligament described in text, detached from its origin at inner border of the plantar aponeurosis; c — flexor hallucis brevis; d — tendon of peroneus longus; e — fibular portion of plantar aponeurosis; f — sulcus between tibial and fibular portion of the aponeurosis; g — long plantar ligament; h — deep attachments of the aponeurosis to 4th metatarsal bone. (Processes to the other metatarsal bones removed.)

in Fig. 27) curved medially and attached itself to the plantar surface of the 1st cuneiform, forming a septum along the adductor hallucis brevis muscle.

B. The Writer's Observations

Perusal of the literature shows that the plantar aponeurosis has been studied somewhat cursorily when compared to the thorough

studies made by several workers on the palmar aponeurosis. The present writer has therefore endeavoured to make a closer study of the structure of the plantar aponeurosis by means of 40 dissections. The material consisted of post-mortem sections from adults of both sexes and varying ages.

It was possible, by careful dissection, to follow the continuations of the aponeurosis to the lateral aspects of the proximal phalanges, as well as to the dorsal fasciae of the toes in analogy with the conditions in the upper extremities. This was not the case as regards the big toe, since the aponeurosis there shows no distinct continuation peripherally of the metatarsophalangeal joint. The digital extensions were thin and insignificant compared to those going to the fingers.

Since the pathological changes discussed in this chapter appear particularly to take place at the medial border of the plantar aponeurosis in the hollow of the foot, special attention was paid to the structure of the aponeurosis in this region. Even before the writer had read HENKEL's above-mentioned paper, it was always possible in the dissections to isolate two bands in this region with their origin in the aponeurosis. They form oblique definite fortifications of the medial septum, about a centimetre in breadth, at the site where the tendon to the flexor hallucis longus muscle penetrates it to the medial aspect (Fig. 28). The medial slip which has its course most proximally is the most pronounced and is attached, not only to the 1st cuneiform, but also to the plantar aspect of the 1st metatarsal bone. The anatomical structure within this region is further complicated by the fact that, on the medial aspect, a tendinous partition fuses with the short medial muscles of the foot and gives partial origin to these muscles. The lateral slip shows, on the whole, the course described by HENKEL (Fig. 27). It proceeds at right angles from the medial border of the aponeurosis in a dorsal direction.

The plantar aponeurosis is thus very tensely fixed to the skeleton by means of these bands. This anchorage in the hollow of the foot certainly has a definite influence on the statics of the foot and functional significance as well. (This question will be discussed further on p. 82).

As regards the functions of the plantar aponeurosis in general, reference is made to BENNINGHOFF's text-book, particularly as regards the complicated coordination between the fibrous and muscu-

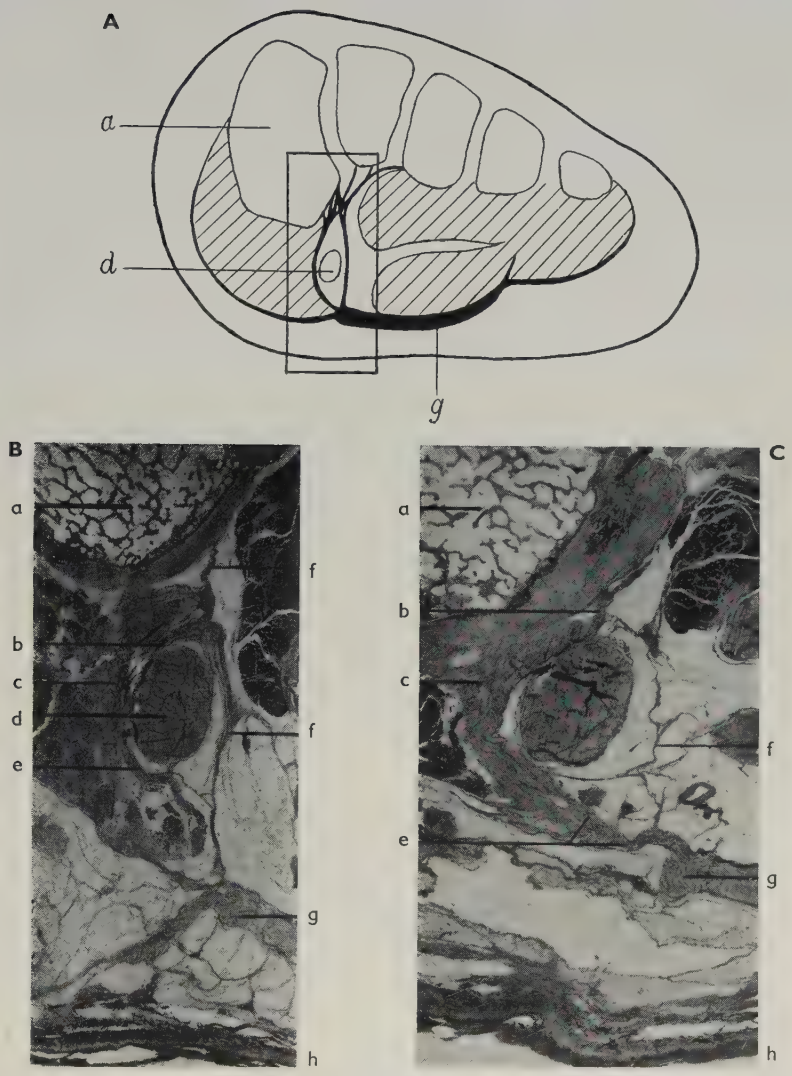


Fig. 28. Transverse sections of the medial portion of the foot in an adult at the level of the first cuneiform bone, B about one cm distally to C; both corresponding to the square in diagram A. The photomicrographs illustrate the reinforcement by two bands of the deep vertical septum from the inner border of the plantar aponeurosis, one on each side of the flexor hallucis longus tendon. The lateral band is well developed only in section A. Stained with haematoxylin-eosin. (× 4.)

a — first cuneiform bone; b — deep attachment of medial band from the plantar aponeurosis; c — partial origin of the flexor hallucis brevis; d — tendon of the flexor hallucis longus; e — medial band; f — lateral band; g — plantar aponeurosis; h — plantar skin.

lar supporting systems of the foot. If the aponeurosis is severed transversely, the arch of the foot falls.

C. Embryology

The human embryology of the plantar aponeurosis was studied by Bruno (1933) from the 11 to 48 cm stages. He was able to follow the development of a fibular and a tibial portion.

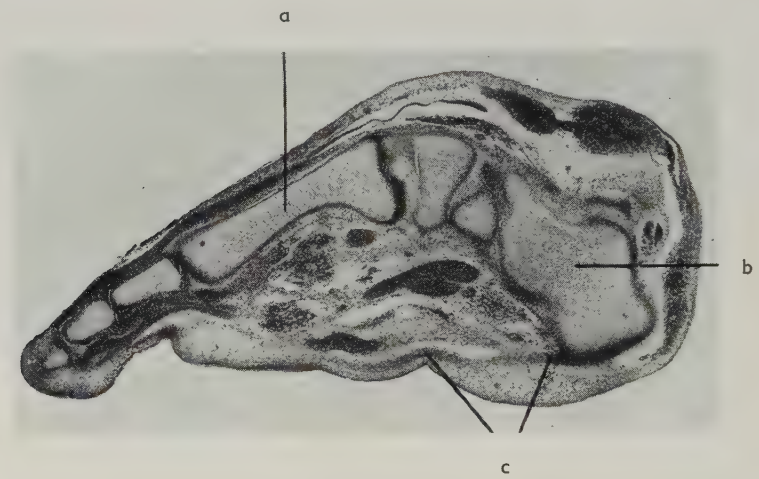


Fig. 29. Longitudinal section of medial part of the foot in a 3.3 cm human foetus. Stained with haematoxylin-eosin. (× 25.)

a — metatarsal bone; b — calcaneus; c — plantar aponeurosis.

An account of the development of the palmar aponeurosis based on an investigation of 20 human embryos and foetuses in various stages is given in Chapter I of the present paper. The plantar aponeurosis was studied in the same material. It was then observed that the development of the latter started later than that of the corresponding structures in the hands. This is in agreement with the general rule that morphogenesis occurs later in the caudal segments. Fig. 29 shows the tibial portion of the aponeurosis at the 3.3 cm stage. The development in the upper and lower extremities showed such good agreement that the description given above of the hand can serve for analagous features in the foot. Thus the natatory ligaments were formed from separate primordia.

2. Clinical Section

A. Survey of the Literature

Changes take place, as has already been mentioned, in the plantar aponeurosis similar to Dupuytren's contraction of the palmar aponeurosis. Little attention has been paid earlier to these conditions and no complete collection has been made of cases of this kind observed previously. Dupuytren mentioned that retraction of the toes was also caused by a shortening of the plantar aponeurosis, but he did not report any illuminating case, nor was the coincidence with genuine contraction of the fingers mentioned. It is uncertain to which pathological condition of the foot he referred.

A careful study of the literature reveals, however, that single cases with localized changes of the plantar aponeurosis analogous and concomitant to those of the palm have been reported by Madelung (1875), Reeves (1881), Costilhes (1885), Souza-Leite (1886), Adams (1892), Anderson (1897), Féré (1899), Daeschler (1903), Teschenmacher (1904), Stein (1909), Byford (1921), Specklin, Stoeber (1922), Silva (1924), Cokkalis (1926), Kinzel (1927), Auvray (1929), Nippert (1929), Rouillard, Schwob (1931), Fairbank (1932), Schröder (1934), Greenberg (1939), Hohmann (1941), Klossner (1944), von Stapelmohr (1947).

Among their 29 cases of Dupuytren's contraction, Kanavel et al. (1929) reported involvement of the feet in two cases. In a third patient there was a marked cord-like thickening in the subcutaneous tissue of the soles of the feet, closely simulating the fascial thickening of the palm in cases of Dupuytren's contraction before flexion contraction has occurred. Meyerding (1936) found feet and hands affected in four cases out of 273. Bunnell (1944), in a material of 87 contracted hands, reported three cases with the association of a similar condition in the plantar fascia.

Powers (1934), feeling that Dupuytren's contraction of the feet had been awaiting re-discovery since it was first mentioned by Dupuytren, found it present in 9 of 29 cases of this disease. His report must, however, be regarded with some criticism. In only three of his cases was a description of localized changes in the plantar aponeurosis given, and most of them were combined with vascular disturbances, hypertrophic skin diseases and pain — symptoms generally not associated with Dupuytren's contraction.

An interesting report on this co-existence was given by Lund (1941), who found "fibroma plantae" present in 25 of 361 *epileptics*; 22 of them also had Dupuytren's contraction of the hands. In 1,021 brewery workers examined there was only one case with a similar affection of the foot.

It can be deduced from all the above-mentioned cases, from which it is possible to form an idea of the closer localization of the process in the plantar aponeurosis, that it was limited to its medial portion, in the hollow of the foot, possibly spreading in the line of the big toe. The symptoms were usually insignificant and only occurred in some cases. These were manifested as feelings of pressure in the form of tenderness, or a burning sensation in the sole of the foot, discomfort in walking or running or carrying weights. Deformation of the foot was only mentioned in four cases. Auvray stated that the big toe on the affected side was in the flexion and valgus position, but it should be noted that the entire foot was in the valgus position and that the leg was atrophic. Cokkalis reported decreased dorsal flexion of the big toe in his case. Fairbank's case with typical thickening and contraction of the interior aspect of the plantar aponeurosis of both feet showed some degree of cavus. In only one of Lund's 25 cases had the condition caused incipient contraction of the toes.

Finally, it will be shortly summarized how the double appearance of Dupuytren's contraction in the hands and feet affected opinions on the *aetiology* of the disease. Reeves had seen contraction of the plantar aponeurosis in a sailor, "who was much in the rigging barefooted". Féré, Black (1915) and Lund, however, were of the opinion that when hands and feet were found to be similarly affected, this almost proved the disease to be entirely independent of mechanical cause.

Souza-Leite's case had suffered from repeated strokes accompanied by transient paresis. This fact was considered to demonstrate the trophic nature of the phenomenon. Nippert believed that decreased tonus of the sympathetic nervous system was the cause, whilst Power regarded it as a sign of irritation of the sympathetic nervous system. Neurogenic theories were also brought forward by Specklin, Stoeber and by Rouillard, Schwob. In the latter case the cause was thought to be a vascular lesion of the spinal cord due to syphilis. Fredet (1932) and Bunnell drew attention to the fact that the disease was more pronounced over the internal than over the external plantar nerve and that the latter corresponds to the ulnar nerve in the hand.

Endocrine disturbances owing to syphilis were assumed by Silva

to be the cause. Syphilis in conjunction with chronic alcoholism was the theory postulated by Auvray.

Cokkalis, Kinzel, and Klossner regarded their cases as support for Krogius' theory and interpreted the pathological tissue as degenerated rudiments of a superficial plantar muscle occurring in earlier phylogenetic stages.

Finally, Daeschler connected his case with metal intoxication, and Hohmann considered that the symmetrical appearance in hands and feet was a sign of constitutional disposition. (These theories will be discussed in the chapter on Aetiology.)

B. The Writer's Observations

43 of the patients reported on here for Dupuytren's contraction of the hands were also examined with regard to involvment of the feet. Ten of them, all men, showed changes in the plantar aponeurosis. In two of them, however, the deviations from the normal were doubtful. If these two cases are excluded Dupuytren's contraction occurred in both hands and feet in 18.6 per cent. (Fig. 30 shows a typical case.) It is improbable that this material should show an exception in this respect, and several reasons to account for the fact that such a frequency was not earlier observed can be found. Such involvements of the feet have certainly often been overlooked, since their course is usually without subjective symptoms and they are not revealed on cursory examination. The subcutaneous tissue and thick skin of the sole of the foot make it difficult to detect an early stage. This is facilitated if the aponeurosis is stretched by extension of the toes.

In all cases of Dupuytren's contraction in both hands and feet the patients had pronounced changes in both hands. In 4 cases both feet were involved. The process was localized to the medial part of the plantar aponeurosis and the site of predeliction was over the base of the 1st metatarsal bone. The changes were found at this site in 7 of the cases as firm nodules varying in size from that of a pea to double that of a bean. Only in one case was there a more extensive thickening of the medial border of the aponeurosis. The skin was not involved in a similar manner to that of the hand, and the characteristic dimpling of the skin within that area was never seen in the feet.

In the four patients who were able to state when the changes occurred in the feet, they had taken place between the ages of 26 and 45, and had persisted from 6 months up to 13 years. In one case the

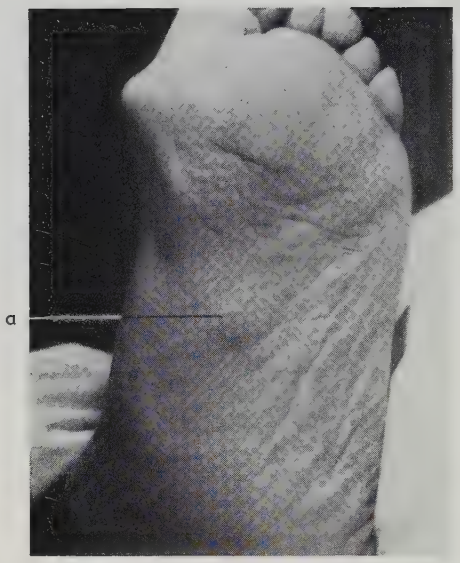


Fig. 30. Typical localization of nodular thickening (a) of the plantar aponeurosis in a patient with Dupuytren's contraction of both hands.

process had remained unchanged for 8 years, after making its appearance as a nodule in the aponeurosis of the foot (Case C. R. S. p. 75). It is interesting to note that in one of the patients the disease appeared in the foot before it appeared in the hands. The case history was as follows:

Case L. J. Naval officer, aged 43. The disease started in the right foot without known cause at the age of about 30 as a limited induration of the medial part of the plantar aponeurosis. (The patient had sustained a fracture of the right foot 5 years previously, but had otherwise suffered no trauma.) The induration was tender and hurt on walking. His condition became so disabling after about 2 years that the changed part of the foot was excised (at another hospital). A relapse occurred immediately afterwards. During the following years Dupuytren's contraction started to develop in both hands, and showed after approximately 8 years a severe bilateral deformity. The left plantar aponeurosis was then also affected.

8.12. 44. *Feet:* Massive deposits in both plantar aponeuroses with large lumps of firm tissue in inner aspect along inner margin. He had pains in his feet when walking and could only walk short distances. There were no other disabilities. No deformity of feet.

9.10. 45. (Op. McI.). Bilateral excision of fibrous tissue masses which proved to be attached to plantar aponeurosis with deep continuation.

12.8. 46. No sign of recurrence. Movements of toes free. No disability in walking.

The pain experienced on walking reported by the above-mentioned patient was, in all probability, chiefly due to mechanical reasons, caused by the pressure of the firm newly-formed tissue. The process

was only widespread in this one case. The discomforts were only minor in all the other cases which is indicated by the fact that three of the patients were not aware of the changes in the plantar aponeurosis until they were revealed on examination. Subjective discomforts only occurred in one other case:

Case L. B. Army officer, aged 47. Bilateral, characteristic finger contraction, from which his father also suffered. The disease started at the age of 24 and had been treated surgically on two occasions. At the age of 45 he noticed a lump in the sole of his left foot. This gave him no disability except for itching and a stretching feeling, which sometimes woke him at night. He rubbed the foot and the feeling then disappeared in a few minutes. No pain on walking.

13.8. 46. *Right foot.* When the big toe was extended, the medial border of the plantar aponeurosis became palpable as a dense band and showed a firm nodule, slightly larger than a pea, corresponding to its middle part. There was a possible slight limitation of the extension of the big toe, but the patient was able to stand on his toes without difficulty. The foot was normal in shape. *Left foot:* normal.

Since it seemed possible that partial disablement of the right foot was imminent, the patient applied to the Ministry of Pensions to register this disease as Dupuytren's contraction. His application was refused on the grounds that a localization in the foot did not exist in this disease!

None of the patients showed any flexion contraction of the toes or other foot deformities which could be connected with the changes in the aponeurosis. The following case will, however, be discussed further in this respect.

Case C. R. S. Accountant, aged 34. No heredity of Dupuytren's contraction to the patient's knowledge. Both hands affected, starting in the right hand at the age of 21 and in the left hand eleven years later. At the age of 26 he developed a localized thickening in the left plantar aponeurosis, not increasing in size or giving any kind of disability during the following years. The cause of the disease was unknown to the patient.

On admission to hospital 13.8. 46 for operation of the right hand, a thickening slightly bigger than a pea could be felt on the inner border in the middle part of the *left plantar aponeurosis*. There was a marked hallux valgus, but otherwise no deformity or disability of the foot.

The *right foot* showed the same degree of hallux valgus but no involvement of the plantar aponeurosis. 15.8.46. (Op. T. S.) The fibrous thickening of the *left plantar aponeurosis* was excised for microscopical examination. Operation revealed that the adjacent parts of the aponeurosis were normal. The longitudinal incision healed primarily and the patient had no disability from the operation.

The last case reported is interesting in comparison with that described by Auvray, who reported that the big toe was drawn in the flexion and valgus position. This can hardly be ascribed to a retraction of the palmar aponeurosis. As already mentioned, the extension to the big toe is the shortest, and is attached practically only to the first metatarsal bone and to its accessory plantar ligament. If on

an anatomical preparation this extension is pulled, the dorsal flexion is prevented in the metatarsophalangeal joint, but no flexion is caused. If the big toe is adducted a pulling of the extension attempts to return the toe to its normal position. In favour of the opinion that shrinkage of the plantar aponeurosis did not cause the valgus in the big toe is the fact that in the case described by the present writer the degree of hallux valgus was the same on the other side, in which the aponeurosis showed no changes.

It can also be seen, from the cases reported in the literature, that they are only exceptionally accompanied by notable deformity of the feet. This surprising fact was considered by KLOSSNER who thought that the explanation lay in the anatomical structure of the plantar aponeurosis. He based his theory on the statements in RAUBER-KOPSCH's handbook of anatomy that the plantar aponeurosis lacks any extension peripherally of the metatarsophalangeal joints.

As mentioned above, the present writer found on dissection that this was true of the big toe but not of the other toes. Their anatomy corresponds in this respect to that of the fingers with slight but nevertheless definite extensions to the toes. The writer therefore only agrees with KLOSSNER's explanation in so far as it concerns the medial part of the plantar aponeurosis. It must also be emphasized that, even in other respects, the conditions for the occurrence of a flexion contraction of the toes differ from those of the fingers. This is because the four lateral toes are normally hyperextended in the metatarsophalangeal joints and the flexion capacity is relatively small in these joints. Moreover, such contraction is counteracted when walking. As far as the writer is aware, however, only the medial part of the plantar aponeurosis was affected in the cases hitherto described.

Theoretically, it could be expected from the anatomical conditions that a shrinkage of the digital extensions of the plantar aponeurosis to the four lateral toes would be the cause of the same faulty position as in hammer toe. Only one case appears to support the possibility of such an assumption.

Case H. L. (Fig. 31) A woman, 74 years old. Bilateral finger contraction developing during the last ten years. Typical pea-sized nodule in the medial border on the left plantar aponeurosis. Since youth bilateral hammer toe in the three ulnar toes without known cause. Examination revealed a shortening of the soft parts of the plantar aspect of these toes, but no definite cords or nodule formations. The toe joints appeared to be normal.

Fig. 31. Hammer toe position of the three lateral toes in Case H. L. p. 76.

Without microscopical examination this single case does not allow of any definite conclusions regarding the origin of this hammer toe position. The question whether the digital extensions of the plantar aponeurosis play a rôle in such a deformity is, nevertheless, worth consideration in the future.

Of 207 male *epileptics*, 7.8 per cent showed the typical localized changes in the plantar aponeurosis described above. 86 of the epileptics suffered from Dupuytren's contraction in the hands. The percentage in which the feet were involved in this latter group was 15.2 per cent, a figure very nearly in agreement with that in the cases operated on (18.6 per cent) and with LUND's observations. (For distribution according to age, and other information, see p. 99.)

3. Pathology

A. Survey of the Literature

Only a few of the cases reported in the literature suffering from Dupuytren's contraction localized to the plantar aponeurosis have been examined microscopically. GREENBERG described the excised thickened plantar aponeurosis as extremely dense and firmly adherent to the skin and to the muscular portion of the flexor brevis

digitorum. The specimen showed "spotty hyperplasia" of the connective tissue and enormous hypertrophy of the adventitia of large veins and arteries. The case of MEYERDING et al. "presented all the appearances of normal fascia, microscopically," but around the fascial bundles there were numerous new capillaries with perivascular lymphocytes. Their description causes a suspicion that the section did not include the characteristic nodular thickening of the aponeurosis. HORWITZ examined a nodule removed from the plantar aponeurosis of a 48-year-old woman in whom the palmar aponeurosis was apparently not involved. He regarded the histological structure as similar to the fibroplasia occurring in Dupuytren's contraction. WIMTRUP, who examined LUND's cases, reached the same conclusion. KLOSSNER pointed out that the pathological tissue in the hand and the foot were identical, but interpreted the cellular areas as derivates of persistant embryonic tissue.

To sum up, it can be stated that in the few cases reported, with the exception of those of Meyerding, the microscopical structure appeared to be typical in all respects of Dupuytren's contraction.

B. The Writer's Observations

The material consisted of four preparations from different feet (Case L. J. p. 74, (bilateral); Case C. R. S. p. 75; and Case L. M. p. 79).

Macroscopical examination revealed the pathological tissue as nodular indurations of diffusely defined, firm scarlike tissue interrupting the homogeneous, longitudinal structure of the aponeurosis (Fig. 32). The cut surface showed fibrous streaks in various directions, chiefly longitudinal.

Microscopically, the process was characterized by connective tissue in forms varying from new connective tissue with little intercellular substance to fibrous tissue relatively poor in cells. In the zone of transition to the normal aponeurotic tissue, breaks in the normal structure of the collagen fibre bundles of the aponeurosis were seen. It was also possible to follow at these sites how the new connective tissue originated from the perivascular tissue of the surrounding blood vessels (Fig. 33). These blood vessels showed a definite reaction, with dilatation and a perivascular increase of cells, consisting of

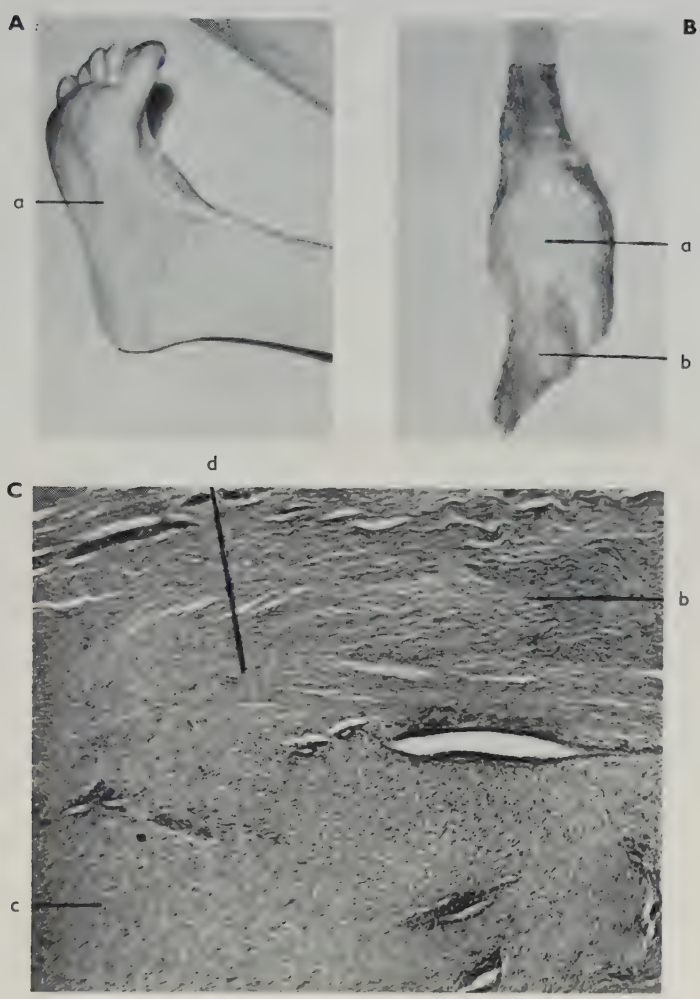


Fig. 32. Case L. M., aged 43. Severe Dupuytren's contraction of both hands began at the age of 32. 14.8.1945 admitted for operation on hands. *R. foot:* Inner border of the aponeurosis thickened by a firm painless nodule (**A**) giving no disability. Note free extension of the big toe. The thickening was excised and appeared to consist of localized scar-like fibrous tissue interrupting the normal structures of the plantar aponeurosis (**B**). Examined in 1946 there was no recurrence, but a similar small nodule had appeared in the left foot.

C — Photomicrograph showing longitudinal section of the specimen illustrated in B. Typical histological structure of Dupuytren's contraction. Stained with haematoxylin-eosin. (× 60.)

a — nodular thickening of the plantar aponeurosis; b — normal aponeurotic tissue; c — area with hypercellular connective tissue; d — borderline between the aponeurosis and the tissue of the nodule. Note how the structures of collagen fibres coming from the aponeurosis are interrupted in this zone.

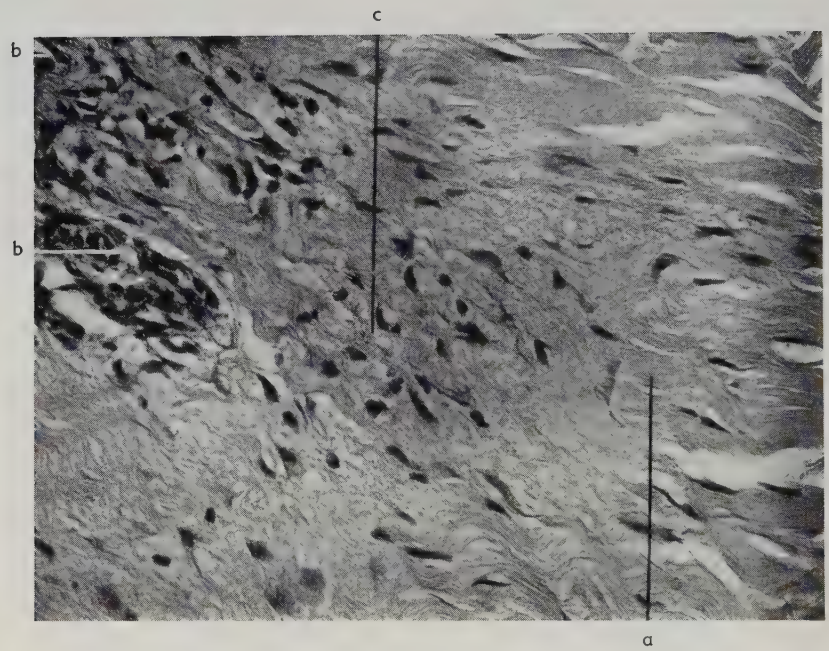


Fig. 33. Photomicrograph from the nodule in Fig. 32, showing what the writer regards as the primary tissue reaction in Dupuytren's contraction. Stained with haematoxylin-eosin. (× 370.)

The collagen fibres (right of the field) are frayed and have a wavy course breaking their normal structure (a). The adjacent area (c) which is strongly basophil has been invaded by young connective tissue cells and a few white corpuscles. This new formation of connective tissue clearly orginates in the neighbouring perivascular tissue (b) of fibroblasts.

new connective tissue with plentiful cells but also a few round cells and white corpuscles.

In the foot, in which the mechanical strain on the newly-formed tissue is chiefly longitudinal, it was not surprising to find in the later stages a preponderantly longitudinal arrangement of these structures. When the process had extended outside the actual aponeurosis, the tissue showed parts whose axial arrangement was crossed on various planes. It was possible to demonstrate the presence of iron pigment in the centre of the cellular areas.

The material appears on the whole to agree with the individual observations made by earlier workers. A comparison with corresponding preparations from the palmar aponeurosis in the writer's

material showed that they were identical in all important respects. The writer therefore refers to the statements made concerning the microscopical picture in Dupuytren's contraction in the hand for a more detailed account.

4. Pathogenesis

In all the cases reported by the writer, the changes were localized to the medial aspect of the aponeurosis and, practically without exception, to the middle of the hollow of the foot. This is somewhat remarkable in view of the varying picture shown by Dupuytren's contraction in the hands. The uniform, almost identical development of the disease in the plantar aponeurosis and its arrest at quite early stages makes an attempt to interpret the nature of the process particularly inviting.

Even the macroscopic appearance of the diffusely limited, fibrous nodules which interrupt the homogeneous tissue of the normal aponeurosis give an immediate impression of a formation of scar tissue. It is therefore easy to suppose that these nodules develop as a result of a rupture in the aponeurotic tissue. The question then arises: does the aponeurosis in those parts which are affected show a structural weakness, or are these parts subjected to particular strain? The writer was able to ascertain by dissection that the development was as powerful in the regions of predilection as in those adjacent to them but that there was a localized anatomical difference — the septum which penetrates into the sole of the foot from the medial border of the aponeurosis is strengthened at this site by bands, described in detail above.

On closer consideration it appears very probable that the functional demands are exceptional in this region. The aponeurosis stretches in the form of a fibrous arch from the os calcis to the anterior aspects of the metatarsal bones. It is most powerful and most arched on the medial aspect and slopes towards the lateral aspect. When subjected to weight, e. g. when standing, the weight of the body attempts to create a flattening of this arch. The strain is naturally greatest on the most arched, medial part of the aponeurosis. This flattening is counteracted by the septum which proceeds from the medial border of the aponeurosis and which anchors the arch to the

bony structure of the foot. The force which tends to bring the aponeurosis into a bowstring position should not, according to mechanical principles, be the same in the various transverse sections but greatest at the largest curve of the arch. The ligamentous bands which attach the aponeurosis at this point appear to afford further evidence that there is particular strain here. All these schematic details of the mechanism of the aponeurosis are not identical in all feet, since there are individual variations in the shape of the arch of the foot, the anatomical details and the interaction between the passive and active supporting structures of the foot. One important conclusion can, however, be reached from the above argument, i. e. that the plantar aponeurosis is generally subjected to the greatest mechanical strain in the middle part of its medial region, thus in that part in which the pathological changes were observed.

The writer has already given good reasons for presuming that Dupuytren's contraction in the hands has its origin in partial ruptures in the aponeurosis. In the plantar aponeurosis, the localization of identical changes to the part on which the functional demands are greatest gives further support to this opinion. Moreover, vice-versa, this pathogenetic interpretation gives a satisfactory explanation of this typical localization in the foot. The picture of a nodule of scar-like tissue interrupting the normal fibrous bundles in the aponeurosis is also in good agreement with the theory. The presence of iron pigment in the centre of the nodules also speaks in favour of a primary tissue lesion, as does, to a certain extent, the whole microscopical picture.

An immediate objection to the above theory is the fact that the same external conditions for the cause of a rupture in the aponeurosis are present in persons who do not develop the pathological changes. This fact does not, of course, refute the pathogenetical theory brought forward but shows that, as in the case of the hands, only certain individuals are susceptible to the disease. It can be assumed that decreased strength in the aponeurotic tissue is a disposing factor in these persons in so far as exceptional injury can be excluded. In the cases investigated no such injury had occurred. The question of the aetiology of the disease will be discussed further in chapter VII. A finding made by Ledderhose (1897) will, however, be reported here since it is of particular interest although Dupuytren's contraction was not involved.

Ledderhose had in 50 cases observed and followed the development of nodules in the plantar aponeurosis occurring after a long period during which the leg was in splints (in nearly all cases owing to fracture of the lower leg). The nodules appeared when the patients once more began to support themselves on the injured leg. It can therefore reasonably be assumed that their cause was stretching and partial rupture of the aponeurosis. Practically without exception they appeared at the inner border of the middle part of the aponeurosis and varied in size from a pin's head to a bean.

It was stated that it was necessary to amputate the big toe in one case owing to disabling contraction. In addition, the entire anterior part of the foot was bent in contraction. It cannot be judged from the account given whether this was a result of changes in the aponeurosis. It appears, however, probable that the contraction in this particular case was tendinous or neurogenic. The localized changes usually regressed in the course of months or years. In the five cases in which they caused disability, excision was performed, without tendency to recurrence. No similar changes in the healthy foot were observed in any of the cases.

Since Ledderhose's observations agree with the writer's own findings and conclusions regarding the pathogenesis of Dupuytren's contraction, a short account is given below of a similar case observed by the writer.

Case K. H. A woman, aged 50. In January 1947 she sustained an open fracture of the lower leg, accompanied by paresis of the extensor muscles of the toes. During the three months' immobilization, a slight flexion contraction developed in the toes, particularly the big toe. A few days after the patient began to walk, a bean-sized painful nodule appeared in the middle of the arch of the foot on the medial border of the aponeurosis. This caused discomfort at every step for a few weeks. Later it partly regressed and was no longer painful.

It can be asked what caused this weakness in the aponeurosis on the fractured side. Ledderhose laid emphasis on a circulatory disturbance and it is possible that this may have some significance. In the case described above, an explicable shrinkage of the tissue occurred on the medial aspect of the foot as a result of tendinous contraction. It is thus not surprising that a rupture took place when weight was once more placed on the foot and the aponeurosis was stretched. In Ledderhose's cases, neither the kind of fixation nor other therapeutic details were stated. *It is, nevertheless, evident that two factors were of importance for the changes in the aponeurosis, i. e. the injury caused by load and some predisposing factor in the aponeu-*

rotic tissue. It is also evident that the latter factor was definitely localized and transient in nature since the process only appeared on the injured side and in the majority of cases healed spontaneously. That it was not a question of a specific sequela to the fracture can be deduced from some observations made by FRANKE (1895). He described a transient condition of "Fasciitis plantaris" in five cases during an influenza epidemic, with tenderness and thickening in the medial part of the aponeurosis. He was of the opinion that a site of less resistance had occurred. The symptoms appeared, however, after the infection had subsided and when the patient started to get up.

As already mentioned, only one of the present writer's cases of Dupuytren's contraction had sustained a fracture of the leg (Case L. J. p. 74). He showed typical nodules in the soles of *both* feet in addition to bilateral finger contraction. None of the other patients reported any exceptional strain on the feet with the exception of one, who had done considerable physical training and marching in military service. The case reported by GREENBERG had sustained fractures both of the tibia and fibula and the patient was not quite sure whether involvement of the sole of the foot preceded or followed the fractures. The contraction in the left hand had its onset before the fractures in that case.

Several factors can be thought to contribute to the fact that the disease is less common and less severe in the feet than in the hands. With regard to the pathogenesis postulated in the present paper, it is evident that the plantar aponeurosis is well protected from external injury and that only its medial part is exposed to considerable internal strain. Moreover, the factors which affect the plantar aponeurosis are practically without exception in a longitudinal direction, and the tissue is of homogeneous tendon-like structure, well-suited to withstand these strains. In this respect it differs from the palmar aponeurosis with its complicated arrangement of fasciculi which are transversed on different planes and thus form a relatively weaker protection against the varying strains to which the hand is exposed. In addition, the perpetual training in walking keeps the plantar aponeurosis in good functional condition. Finally it must be emphasized that, should a rupture occur in the aponeurosis, the act of walking counteracts shrinkage of the scar tissue and thus prevents retraction which could otherwise cause fresh ruptures and thus lead to a progression of the process.

5. Treatment

Klossner and von Stapelmohr have earlier treated one case each with excision of the affected part of the plantar aponeurosis. According to their statements, the results were satisfactory.

It was stated that treatment is seldom required. Of the eight cases observed by the present writer, only one (v. p. 74) was obliged to seek treatment owing to pain when walking. In this case excision was made since the symptoms were apparently mechanically conditioned. It is interesting to note that the symptoms were said to recur shortly after operation. The process then progressed and a new operation was necessary. It is not known whether the pathological tissue was radically excised at the first operation. At the second operation the excision extended to the normal tissue. On re-examination one year later there was no recurrence. In two cases in which the nodules caused no subjective discomforts, but in which excision was performed for scientific purposes, there was no recurrence either.

The incision should be made as medially as possible in order to avoid a disabling scar on the sole of the foot. All pathological tissue should be excised. The present writer does not, however, believe that it is necessary to make as radical an intervention as in the case of a similar condition in the hand, in which it has been found expedient to remove the entire aponeurosis and not only the pathological tissue. This opinion is supported by the following reasons:

1. A radical excision of the diseased part in three cases, one of which was bilateral, did not give rise to recurrence.

2. The progressive tendency of the disease is relatively small in the foot and does not often cause deformity. Aponeurosectomy is thus scarcely indicated since it would be accompanied by considerable functional disturbance.

3. Re-operation is easily performed should it become necessary.

Surgical intervention is only indicated on the grounds of subjective discomforts. Operation for prophylactic reasons cannot be considered justifiable since the process shows little tendency to progression and thus generally remains harmless.

CHAPTER V

Dupuytren's Contraction in Relation to Some Similar Changes in Connective Tissue

1. "Knuckle-pads"

A. Survey of the Literature

Among minor signs of gout, PAGET (1875) mentioned "the formation of abnormal bursae" most commonly encountered over the articulation between the first and second phalanges of the fingers. The dense nodular mass was situated in the subcutaneous tissue only and the joint itself could be quite healthy and perfectly movable. In 1893 GARROD described more accurately three cases with subcutaneous nodules on the dorsal aspect of the proximal interphalangeal joints. Though this condition is not rare and there is little to add to his description of its clinical features, it nevertheless seems to be very little known. This condition was termed *knuckle-pads* by GARROD, and in accordance with this, KRANTZ (1938) wrote on "Fingerknochelpolster" and COSTE et al. (1942) on "Coussinets des phalanges". KREINER (1928) described similar changes as "symmetrischer Fibromatose".

KRANTZ already pointed out the term helodermia, taken from GOTTRON, to be incorrect and the following description will show terms such as "callosités dorsodigitales", "keratomes en nappe de mains", "keratosis supracapitularis" to be inadequate.

PAGET did not mention this condition in conjunction with Dupuytren's contraction. But GARROD (1893) already in his first article on knuckle-pads noted the coincidence with this contraction. Of his twelve cases reported in 1904 — 7 males and 5 females — six had finger contraction as well. He was also inclined to believe that the

nodules originated in bursae and suggested a constitutional (possibly gouty) origin for them. In single cases coincidence of these hand diseases was reported later by WHITE (1907), H. W. JONES (1923), WEBER (1938), COSTE et al. (1942). KROGIUS (1921) found, in a family in which several cases of Dupuytren's contraction had occurred, that nodules on the fingers, which he interpreted as gouty nodules, were present. BACKMAN and SPROGIS (1925) also found in a similar investigation six persons with nodules over the finger joints. One of them also had finger contraction. They were of the opinion that the nodules were a hereditary symptom sometimes appearing instead of Dupuytren's contraction. COSTE et al. also assumed this symptom to be hereditary. In series concerning Dupuytren's contraction only OEHLECKER (1930 a) described two cases with "symmetrical fibroma over the finger joints". SEZARY and BOLGERT (1942) interpreted knuckle-pads as an indication of latent scleroderma.

In 100 male *epileptics*, LUND (1941) found 29 with knuckle-pads and 21 had Dupuytren's contraction in addition. In 100 female epileptics the corresponding figures were 13 and 8. In 1,002 brewery workers knuckle-pads occurred in 1.3 per cent only, thus the frequency among epileptics was about twenty times higher than among non-epileptics.

Since knuckle-pads cause very little inconvenience they are not usually treated surgically and statements regarding their microscopical structure are therefore rare. WHITE gave a histological account of this condition in one case and regarded it rather as a new growth of fibrous tissue than as ordinary subcutaneous fibromata. HAUCK (1924) found the pads to consist of irregular fibrous tissue and described them as subcutaneous fibromata. JONSSON (1947) regarded the tissue changes as similar to those occurring in Dupuytren's contraction in one case, although the palmar aponeurosis was not apparently involved.

Knuckle-pads should not be confused with Heberden's nodes. These only occur at the distal interphalangeal joints and are not movable, since they are bony periosteal projections on the phalanges. A knuckle-pad may have the appearance of a bursa but the latter is usually soft and contains fluid. It has never been proved that knuckle-pads originate in bursae or bursal rudiments. Usually there should be no difficulty in making a differential diagnosis in respect of either gout or polyarthritis.

To sum up, it can be stated that Dupuytren's contraction was observed in a few cases with knuckle-pads. This resulted in some vague speculations, amongst others that gout could be a common cause of both conditions. With the exception of the cases of epileptics it has not, however, as yet been demonstrated that knuckle-pads are common in patients with Dupuytren's contraction.

B. The Writer's Observations

Of the 50 patients with Dupuytren's contraction investigated by the writer, no less than 22 had nodules over the proximal interphalangeal joints of one or more fingers. Fig. 34 shows a typical case of such knuckle-pads. The two women examined had no knuckle-pads, but as seen from the literature, the condition occurs in both sexes. In 18 cases the changes were bilateral and in 4 unilateral. In 11 cases all the knuckles were involved in some degree, but in none of the cases were there similar changes over the interphalangeal joint of the thumb. As did Hauck, the writer found the nodules most pronounced on the ulnar fingers. Where only individual fingers were involved, the distribution between the fingers in 11 hands was: index 2; middle finger 3; ring finger 5; little finger 6.

There was no particular predominant frequency in any age-group; the youngest patient was 25 and the oldest 65 years old. Of those who were able to indicate when the knuckle-pads started to develop, nine stated that this had occurred before they had noticed signs of Dupuytren's contraction, in one case 20 years before. In three patients the knuckle-pads appeared 4 to 15 years after the development of finger contraction and in two cases the onset was simultaneous.

No relation could be shown in the material between knuckle-pads and the degree of Dupuytren's contraction, nor was the occurrence of the former confined to those fingers involved by the contraction.

The nodules were quite painless, but in three cases they were tender when they first appeared and four patients stated that their knuckles were sore when knocked or in cold. The nodules appeared gradually and without known cause, although one patient believed that they were the result of trauma.

The nodules were fairly well-defined, round or somewhat irregular

Fig. 34. Case K. P., aged 37, showing typical knuckle-pads over the proximal interphalangeal joints of index, middle, ring and little fingers. They were supposed to be caused by the patient having his knuckles knocked in his work. Note subcutaneous thickening in the ulnar part of palm proximal to the distal palmar crease indicating the first stage of Dupuytren's contraction.

The knuckles of the left hand were similarly involved. Left hand operated on for typical advanced Dupuytren's contraction. Knuckle-pads had appeared ten years prior to the finger contraction.

in shape and rarely symmetrically developed over the joint. They varied in size from moderate thickenings to bean-size. Their consistency was homogeneous and fairly firm. On cursory examination they could possibly be mistaken for bony projections. X-ray examination, however, always revealed that the abnormality was confined to the soft tissues (Fig. 35). It has been stressed that these subcutaneous nodules are movable over the finger joints but closely adherent to the covering skin. In several cases examined by the writer the skin could be lifted in folds over the nodules and in no case was there close adherence to the skin. The process appeared to be definitely connected to the extensor mechanism of the finger since when this was stretched the nodules could no longer be shifted laterally. When the nodules were localized at the base of the second phalanx, at the site of attachment of the extensor tendon, they were almost immobile. There was little impairment of the flexion capacity of the finger joints involved and their functions were otherwise normal.

Fig. 35. Case S. S., aged 40, with Dupuytren's contraction of right hand. Knuckle-pads were present on left index and both little fingers.
X-ray of left index finger showing knuckle-pad consisting of soft tissue only.

In order to obtain a comparison with the forementioned frequency figures, all the *patients in several surgical wards* (127 men and 103 women) were examined. The number of patients in various age groups from 20—80 years was fairly uniform. Eight of the men had knuckle-pads and four of the eight also suffered from Dupuytren's contraction. (Another stated that his father suffered from finger contraction.) Two of the women had knuckle-pads. If patients suffering from both knuckle-pads and Dupuytren's contraction are excluded, the frequency of knuckle-pads in this control material is 2.6 per cent. This figure, as well as 1.3 per cent in LUND's control material, is thus considerably lower than in cases with Dupuytren's contraction reported above (44 per cent).

Among *epileptics*, who appear to have a predisposition to both these conditions, the writer found that knuckle-pads were present in 35 per cent of 86 cases with Dupuytren's contraction. The frequency in 121 epileptics without Dupuytren's contraction was 20 per cent. LUND's figures for corresponding groups were 38 per cent and 18 per cent respectively. In the writer's material, both hands were involved in 21 cases, the right hand in 13 and the left hand in 19 cases. The distribution according to fingers was: thumb 0; index finger 26; middle finger 40; ring finger 42; little finger 46. Knuckle-pads also occurred in the younger age-groups (Table 7 p. 99), but did not show

a marked increasing tendency with increasing age. It is therefore probable that many of the patients with knuckle-pads only developed contraction later.

Pathology. As three of the writer's patients with Dupuytren's contraction kindly permitted the excision of typical knuckle-pads, it was possible to examine such specimens. A transverse incision was made over the nodule through skin of normal appearance. The nodule was formed of dense fibrous tissue, closely resembling the nodular fibrous thickening of the palmar aponeurosis in Dupuytren's contraction. They were ill-defined and localized to the extensor mechanism of the fingers. Particularly in the two cases, in which the nodules were near the attachment to the base of the second phalanx, it was clearly seen how the aponeurosis-like tendon tissue radiated into the scar-like nodule. Neither the subcutaneous tissue nor the joint capsule were involved.

The microscopical structure of the specimens also showed complete conformity with the changes found in Dupuytren's contraction, with hypercellular irregular connective tissue of varying degrees of maturity in a fibrous structure poor in cells (Fig. 36). The hypercellular areas also contained iron pigment. In actual fact, it was impossible to differentiate microscopically between these preparations and those from the affected palmar aponeurosis of the same patients. This fact has not been substantiated earlier, possibly since the few workers who have examined such formations microscopically were not able to make such comparisons. Their description of the nodules as an irregular fibrous tissue does not, nevertheless, differ in any respect from the present writer's observations.

The specimens did not contradict the opinion of White, i. e. that hypertrophy of the stratum corneum in the covering skin should be regarded as secondary since the pads are prominent and subject to friction.

Discussion. From a practical point of view, knuckle-pads are relatively insignificant. Nevertheless, they would certainly be of more general medical interest if they should prove to be a sign of the same disturbance as in Dupuytren's contraction. The fact that the tissue structure is identical in both instances is not, however, alone sufficient to justify such a conclusion.

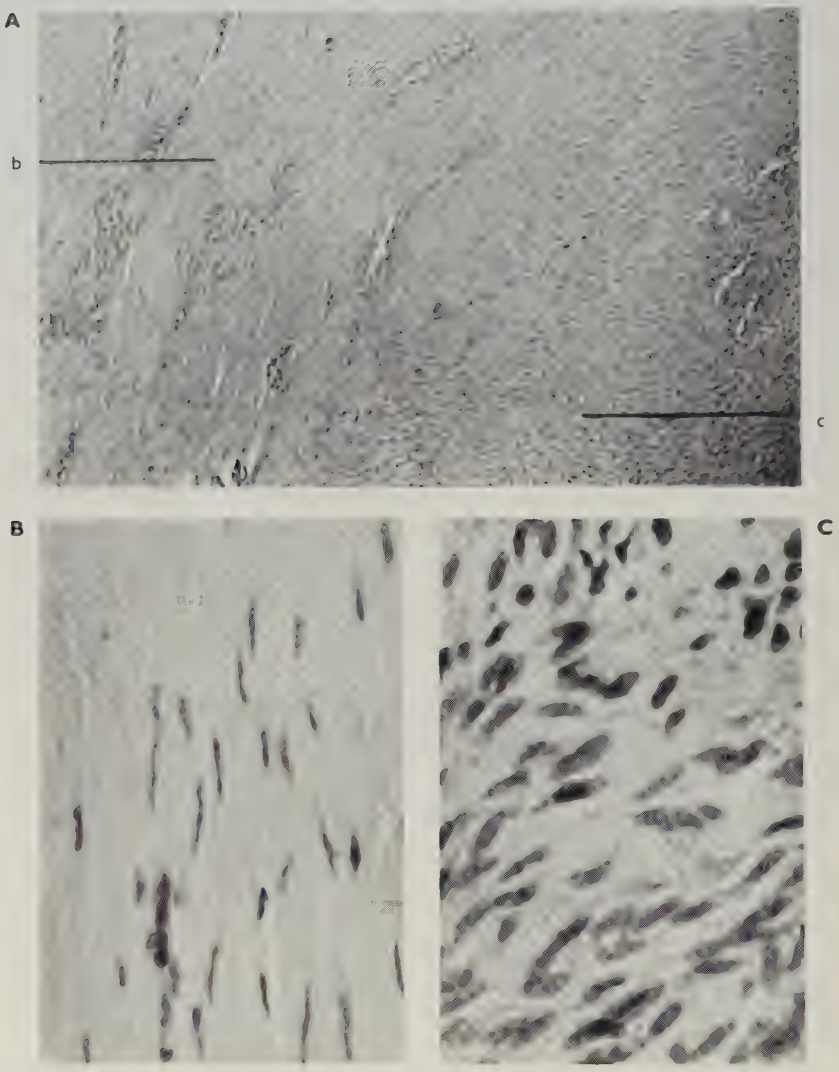


Fig. 36. Photomicrographs showing the histological structure of a knuckle-pad from left little finger in Case O. M., Fig. 48.

A — The aponeurotic tissue of the extensor mechanism of the finger (b) is shown as well as the typical cellular connective tissue hyperplasia (c). (× 80.) **B** and **C** — Sections of the areas indicated in A at a greater magnification. (× 500.)

Compare with Figs. 17 A and B, which show a histological structure typical of Dupuytren's contraction and identical in appearence to that of a knuckle-pad shown here.

The observations made by the writer demonstrate that knuckle-pads occur in an abnormally high frequency together with Dupuytren's contraction and also that epileptics show an increased frequency of both these conditions. It has also been observed earlier that knuckle-pads occur remarkably often in families with a tendency to Dupuytren's contraction. There are therefore several facts in favour of the theory that a predisposition for both these deformities is present in the same individuals. Under such conditions, the identity of the tissue changes is a strong argument in favour of the fact that the same process is present in both cases.

The pathogenesis of these pads will only be dealt with briefly here. The theory already advanced in this paper regarding the pathogenesis of similar nodules in the palmar aponeurosis as a formation of connective tissue resulting from ruptures in the fibrillar elements of the aponeurosis can also be applied to knuckle-pads, since the histological pictures show such extensive similarities. The wide range of flexion of the proximal interphalangeal joints becomes a significant factor if this pathogenesis is assumed. The analogy is further emphasized by the fact that the extensor mechanism of the fingers is of an aponeurotic character in this region. It should also be pointed out that mechanical irritation during healing plays a considerable rôle in the formation of hypertrophic scar tissue.

Functional strain in this region suggests that trauma is a decisive factor for the origin of ruptures in the extensor mechanism, since the knuckles as well as the palm are exposed to more trauma than other parts of the hand. (Cf. the discussion regarding trauma as an aetiological factor in Dupuytren's contraction, p. 130.)

Anatomical conditions as well as functional factors can, in this way, explain why knuckle-pads do not occur over the distal interphalangeal joints or the interphalangeal joint of the thumb.

2. Induratio Penis Plastica (Peyronie's Disease)

A. Survey of the Literature

In this disease of the penis an indurated plaque with well-defined edges is found, involving the septum and the tunica albuginea and usually limited to its dorsal aspect. It is tightly adherent to these structures but not to the skin. The hard fibromatous tissue is said to be keloid-like and almost acellular. Calcific deposits, osteochondrous or osseous metaplasia

of these sclerotic plaques have been demonstrated in about 10 per cent by Sonntag (1921). Its course is unpredictable but regressions are reported (Sachs 1922, and others). The symptoms are painful deflected erections.

A coincidence of this disease and Dupuytren's contraction was first reported by Kirby (1849). In 1906 Neumark described another case and reviewing the literature he was able to refer to twelve similar conditions reported previously. Most of these writers adhered to a theory advanced by Kirby of a gouty diathesis, and specially Hedges (1896) stressed the gouty origin of this phenomenon. Further reports on coincidence of the two diseases have been given by Stein (1909), Smend (1911), Martenstein (1920, 1921), and others.

In 86 patients with Dupuytren's contraction, Costilhes (1885) reported one with fibroma of the penis. In Bunnell's (1944) series of Dupuytren's contraction comprising 87 hands, there were three cases associated with localized fibrous thickening of the penis and von Stapelmohr (1947) mentioned one similar case out of 24 men with finger contractions.

On the other hand, zur Verth and Scheele (1913) found, in 100 cases of induratio penis plastica, that nine patients also suffered from Dupuytren's contraction. Hamann (1938) found no less than 14 (of which two were brothers) with finger contractions in 59 cases. He also reported that Galewsky had only described this coincidence in one of 45 cases but that Callomon had reported a simultaneous occurrence in 10 per cent. Hamann was an adherent of the theory that both conditions were dependent on a special reaction mechanism in the connective tissue. Volavsek (1941) asserted that this reaction was hereditary, since Dupuytren's contraction has this characteristic. He reported a simultaneous occurrence of Dupuytren's contraction and Peyronie's disease in 9 cases out of 198. Lund (1941) in 100 epileptics reported three cases of induratio penis plastica, of whom two also suffered from Dupuytren's contraction.

These statements in the literature will be discussed below.

B. The Writer's Observations

The writer was not able to establish the occurrence of Peyronie's disease in any of the 50 patients treated surgically for Dupuytren's contraction.

There were 7 cases (3.4 per cent) of induratio penis plastica in 207 male *epileptics* examined. Four of these patients also had retraction of the palmar aponeurosis, and in another both the palmar and plantar aponeuroses were involved. These five patients thus comprised 5.8 per cent of 86 epileptics suffering from Dupuytren's contraction. The relatively well-defined, hard induration of the penis was localized in all the cases to the septum, in one case dorsally and near the root, in all the others not far from the glans penis. The size varied from that of a pea to that of a bean. (For the distribution according to age-groups and other details, see p. 99.)

Discussion. Some workers have postulated a causal relationship between Dupuytren's contraction and induratio penis plastica, since these two relatively rare conditions have at times occurred concurrently. In the analogy postulated between the two diseases, the conformity in the age for the onset, the localization to the connective tissue system and the obscure aetiology were pointed out. Even the short description given here of this penile lesion nevertheless brings out several important differences from Dupuytren's contraction. It should also be pointed out that in several cases Peyronie's disease has been considered as a residual lesion following venereal disease, cavernitis, etc.

Individual cases of coincidence are of little value in deciding whether a connexion between Dupuytren's contraction and induratio penis plastica actually exists. There are no statements in larger series of the former disease which warrant such a conclusion, nor does the writer's material support it. It must, however, be mentioned that it has seldom been stated in earlier reports whether the presence of such a disease of the penis was sought. It is therefore possible that it did exist but was not observed. The frequency of Dupuytren's contraction in various series with induratio penis plastica is only abnormally high in HAMANN's relatively small material and this investigation does not therefore justify any definite conclusion.

There are no frequency statistics for the occurrence of induratio penis plastica in general. The figure of 3.4 per cent of mild cases in epileptics appears, nevertheless, to be relatively high. It is, however, interesting that the frequency among epileptics with finger contraction was not much higher (5.8 per cent). To sum up, it must be said

that in the light of present knowledge it is not possible to demonstrate any definite connexion between Dupuytren's contraction and induratio penis plastica.

3. Keloids

A. Survey of the Literature

There are certain similarities between the tissue changes in Dupuytren's contraction and keloids but only a few cases are described in which these conditions appeared in the same patient. A few cases, who in addition suffered from induratio penis plastica, were reported by Martenstein (1921) and Hamann (1938). An interesting observation was made by Sachs (1927) who found three siblings all suffering from finger contraction and keloids. These writers were of the opinion that this coincidence was not accidental. Hamann emphasized that keloids are also hereditary, and of 14 cases of Dupuytren's contraction he stated that keloids were also present in 5. It should be pointed out that this investigation was carried out at a dermatological clinic and that the other cases also had skin diseases.

It is easy to assume a similar abnormal tendency to reaction in the connective tissues in these diseases. The observations regarding the coincidence of keloids and Dupuytren's contraction are, however, as yet too incomplete to permit any such conclusions.

B. The Writer's Observations

None of the patients with Dupuytren's contraction examined by the writer suffered from keloids or stated any tendency to them. The transverse incisions used in the operations on the hands healed neatly. If longitudinal incisions are made in this operation they often cause hypertrophic, retracting scars. This is, however, seen in the majority of hands when such an unsuitable approach is made.

4. Muscular Torticollis

Krogius (1923) regarded the connective tissue formation in muscular torticollis as in some respect analogous to the pathological process in Dupuytren's contraction. He thought the tendon-like bands of the palmar aponeurosis in the latter disease developed from presumed embryo-

nal muscle tissue. Deckner (1938) described a case with finger contraction and caput obstipum. It is true that he believed that both these phenomena were inherited independently but since he found extensive conformities in the microscopical structure, he adhered to Krogius' theory.

A more extensive comparison of these two diseases was carried out by Portius (1936) who examined histologically 24 cases with Dupuytren's contraction and 22 cases with muscular torticollis. He considered that the final stages of both diseases in the form of tendon-like tissue were similar, but that the pathogenesis was entirely different.

Muscular torticollis was not reported in previous large series of Dupuytren's contraction, nor did it occur in the writer's material. There is at present no convincing clinical or theoretical support for the theory of a relationship between the two diseases.

There is still less justification, on the grounds of statements available in the literature, in grouping the conditions described in this chapter, together with various conditions localized to the skeleton, the viscera, the vascular system and metabolic diseases under the common classification "polyfibromatose héréditaire" (Touraine and Ruel 1945). Only a future critical investigation can determine to what extent a connexion exists between such divergent pathological manifestations.

CHAPTER VI

Dupuytren's Contraction and Epilepsy

1. Survey of the Literature

In 1941 Lund reported that among 190 male epileptics of various ages Dupuytren's contraction was present in 50 per cent, and in 171 female epileptics in about 25 per cent. In comparison to 1,021 brewery workers examined he found the palmar aponeurosis involved at least four times as frequently among epileptics. The frequency of similar affection of the plantar aponeurosis, knuckle-pads and induratio penis plastica in these patients was mentioned above. Twelve epileptics had periarthritis humeri. Lund thought that the widespread occurrence of these symptoms among epileptics suggested some pathogenetic connexion between epilepsy (or perhaps between protracted luminal treatment) and these affections. From the fact that acrocyanosis was frequently observed among epileptics, and from experiments on skin-temperature reactions, he believed that Dupuytren's contraction might be due to an affection of the cortical vegetative centres or that the vasomotor functional disturbances accompanying the epileptic fit might be of influence.

It is remarkable that other writers have not found the same high frequency. Féré and Francillon (1902) for example found, in an investigation of various types of mentally diseased patients, only one case of Dupuytren's contraction among 15 epileptics, and one of these writers had only seen two cases of such a coincidence in an institution at which there were always more than a hundred epileptics.

Nippert (1929) described two cases of finger contraction among epileptics but did not state the total number examined.

In large series of Dupuytren's contraction no mention of this disease coincident with epilepsy was made.

Lund's observations of an abnormally high frequency of Dupuytren's contraction among epileptics is, as far as the present writer is aware, the only definite coincidence demonstrated in this hand deformity. Since this interesting observation was only made by one worker and partly contradicts earlier statements, further consideration of the problem is justified.

2. The Writer's Observations

In 1947 the writer examined all the patients (altogether 207 males) at the Svenska Diakonistyrelsen's homes for epileptics at Stora Sköndal and Järna, near Stockholm. The material thus comprised cases in which the diagnosis of epilepsy was definite, and in the majority of cases the disease was severe enough to require care in a closed institution.

The result of the investigation, seen in Table 7, shows that the palmar aponeurosis was affected in 42 per cent of these patients. In 23

Table 7

Occurrence of Dupuytren's Contraction and Similar Changes in Epileptics Examined by the Writer

Age	Number of epileptics	Dupuytren's contraction in hands					Knuckle-pads	»Dup. contr.» in feet	Induratio penis plastica
		Number in grades of severity *				Total I—IV percentage of epileptics	Number	Number	Number
		I	II	III	IV				
10–19	17	1	—	—	—	6	4	1	—
20–29	53	9	1	—	—	19	8	1	4
30–39	58	9	12	3	1	43	20	1	—
40–49	40	9	7	4	2	55	11	7	1
50–59	28	5	7	5	1	64	8	4	1
60–69	10	5	2	2	—	90	2	2	1
70–79	—	—	—	—	—	—	—	—	—
80–89	1	1	—	—	—	100	—	—	—
	207	39	29	14	4	42 %	53	16	7

* Grading according to severity: see p. 159.

For hands and fingers affected and for simultaneous involvement of hands, feet, knuckles and penis, see text.

per cent the process was so advanced that a more or less pronounced finger contraction had developed (Grades II—IV). The disease was abnormally frequent in all age-groups and showed a definite increase with increasing age. If only those over 40 years of age are included, the frequency in 79 cases was 63.3 ± 5.4 per cent. If these statistics are compared with the highest reported earlier in the same age-groups, i. e. 17.8 ± 3.3 per cent, (in workers whose occupation placed a particular strain on the hands, NIEDERLAND, Table 10 A, p. 111) the difference, 45.5 ± 6.3 per cent, is statistically significant. The majority of the epileptics examined were engaged in agricultural work.

Table 7 also shows the occurrence in the material of similar changes in the plantar aponeurosis, as well as of knuckle-pads and induratio penis plastica. In 5 cases there was simultaneous involvment of the palmar and plantar aponeuroses and knuckles, in one case of the palmar and plantar aponeurosis and the penis, and in 3 cases of the palmar aponeurosis, knuckles and penis.

The clinical picture of Dupuytren's contraction in epileptics showed no deviation from the common picture in this disease. In 27 cases the right hand only was involved, in 14 cases the left only, and 45 cases were bilateral. The distribution among the fingers involved was: thumb 1; index finger 0; middle finger 20; ring finger 47; little finger 34.

If the material was divided with regard to the frequency of epileptic fits, the cases with Dupuytren's contraction were fairly evenly distributed in the various groups (Table 8). The palmar aponeurosis was involved to the same extent among patients suffering from severe fits as among those with varying severe and mild fits. It could not be judged whether those suffering only from mild fits were less liable to Dupuytren's contraction, since there were only 14 such cases, of which one had contraction.

TABLE 8

Dupuytren's Contraction in Relation to the Frequency of Epileptic Fits

Epileptic fits per year	0–9	10–19	20–39	40–59	60–79	80–99	>100
Number of epileptics	95	32	29	19	7	3	12
Percentage frequency of D.C.	38	72	24	42	57	67	42

The age of onset of epilepsy did not appear to exert any influence but it can be mentioned that in 87 per cent of the cases the onset was before the age of 19 years. The frequency of contraction increased with the duration of epilepsy. The increase was, however, on the whole in agreement with the observations in Table 7 concerning the various age-groups of the patients. The decisive importance of age in the frequency of Dupuytren's contraction has already been demonstrated. Since the frequency increased in all higher age-groups, it is scarcely possible that the duration of epilepsy could have any great significance. The hand deformity occurred both in patients with idiopathic and symptomatic epilepsy.

To sum up, it can be stated that the writer's investigations confirm, in all important respects, the observations made by LUND.

Discussion

Contrary to LUND the writer cannot consider the results of the investigation to imply that the epileptic fits in themselves should be the cause of the affection of the palmar aponeurosis since no connexion with the frequency of the fits was demonstrated.

It can, nevertheless, be thought that the hereditary tendency for Dupuytren's contraction discussed in Chapter VII can occur concurrently with a tendency to epilepsy. In that case, contraction should be common among the relations of the epileptics. None of the epileptics stated that their relations suffered from finger contraction, but these statements are naturally of little value. Assuming such a hereditary connexion, it could be expected that epilepsy would be common among patients with Dupuytren's contraction. There is no such statement in any of the larger series of Dupuytren's contraction. None of the present writer's material of 50 operated patients suffered from epilepsy, nor did they state that this disease occurred in any of their relations. Moreover, the fact that the hands were involved in cases of post-traumatic epilepsy speaks against the assumption of a hereditary phenomenon.

It is very improbable that the high frequency of finger contraction shown in this investigation and in that of LUND would have been overlooked earlier when attention was drawn to these questions. FÉRÉ (1890) for example, could scarcely have overlooked an involvement of the palmar aponeurosis in his ergometric studies of the

fingers in 134 epileptics but he made no mention of it in his large work on epilepsy, nor did GOWERS (1881). In a paper written in collaboration with FRANCILLON (1902) FÉRÉ actually denied that such a coincidence was exceptionally frequent in epileptics. This fact is in favour of the possibility that the affection of the hand is a relatively new symptom in epilepsy. The question thus arises: are there any environmental conditions in this disease which have changed during recent decades?

FÉRÉ's statements date from the time before phenobarbital (phenylethyl-barbituric acid — "Luminal") therapy was introduced for epilepsy. It appears to the writer that LUND's suggestion that this drug could have contributed to the symptoms deserves attention. He found this supported by the observation that in 38 epileptics to whom luminal had been administered instead of bromide only for two years, 5 only showed the least severe changes of the palmar aponeurosis, whereas from the occurrence in epileptics treated with luminal for many years he would have expected 18 cases (5 of an advanced grade with flexion deformity). In this connexion a clinical observation made by ASK-UPMARK (1944) is of great interest. In certain cardiac disorders he noted a syndrome characterized by humero-scapular periarthritis, swelling of the palmar aponeurosis and oedema of the fingers. He thought that this syndrome was probably of an allergic nature and that the administration of phenobarbital might be of significance. BANDORF-KULLMAN (1939) and others also held the opinion, based on clinical observations, that humero-scapular periarthritis might be caused by prolonged treatment with large doses of luminal. Several more recent observations (LÖVGREN 1948, and others) appear to indicate that phenobarbital gives rise in certain cases to periarticular symptoms of various joints. The development of these symptoms is inhibited if the drug is no longer administered. These later observations support the assumption that these drugs can, in one way or another, influence the connective tissue system.

All the epileptics examined by the writer had been treated with phenobarbital for several years. Unfortunately, it was not possible to obtain data on the exact duration and dosage of this treatment, and in this respect no figures can be given for comparison with the occurrence of Dupuytren's contraction in these patients.

To sum up, it can be said that it is not possible to make a definite statement regarding the cause of the increased tendency to Dupuytren's contraction in epileptics. It is probable that it is independent of the epileptic disease itself, but several facts appear to point to the theory that this tendency can be acquired by such patients and can possibly be connected with lengthy administration of phenobarbital.

CHAPTER VII

Aetiology

I. HEREDITY

1. General Survey

When a disease is rare, it can be suspected to be hereditary, unless any particular causative environmental factors can be demonstrated. Attention has for long been drawn to the fact that Dupuytren's contraction appears more frequently in some families. GOYRAND (1833) was the first to make this observation.

It is evident that statements concerning the familial occurrence of a disease are partly dependent on the worker's knowledge of the family and on how many generations the investigation covers. Table 9 shows the results of a number of such investigations. With the exception of STACKEBRANDT (1932) and SCHRÖDER (1934), however, the writers have as a rule relied on information given by their patients. In many cases this was too incomplete to afford any reliable statistics. It can be seen from the table that the frequency varies very considerably, the highest figure being 40 per cent and the lowest 0 per cent. These statistics give a vague indication that the disease is hereditary, but do not allow of any more definite conclusions.

A familial investigation was carried out in a more satisfactory manner by STACKEBRANDT. Of 17 cases, 5 were stated to have "sichere Heredität" of a chiefly dominant character, since only in one of these five cases did the disease miss a generation, but the woman concerned was assumed to be a carrier. 21 of the 86 persons investigated suffered from the disease. STACKEBRANDT was of the opinion that there are two forms of Dupuytren's contraction, i. e. the hereditary form and the sporadic form. He believed, however, that the latter type was also to a certain extent genotypical and that the disease

TABLE 9

Familial Occurrence of Dupuytren's Contraction

Author	Cases	Incidence in the pedigree
Keen (1881)	198	50
Costilhes (1885)	86	9
Hedges (1896)	60	3
Nichols (1899)	17	6
Janssen (1902)	16	—
McWilliams (1904)	24	2
Krogius (1921)	22	4
Kanavel et al. (1929)	29	8
Oehlecker (1930)	25	3
Wagner (1932)	19	—
Stackebrandt (1932)	17	5
Davis, Finesilver (1932)	40	5
Schröder (1934)	30	10
Maurer (1936)	200	12
Skoog	50	22

occurred spontaneously where the hereditary tendency was particularly strong. It is naturally possible that the sporadic cases are recessive. It is also possible that the five cases of dominance were actually recessive, but had by chance become over-represented, giving an impression of dominance.

SCHRÖDER also investigated the hereditary conditions in his 30 cases and considered that he could establish dominant heredity in 10 cases. He classified two further cases as irregularly dominant, since the mother had transmitted the disease although she did not herself suffer from it. 89 persons were investigated in these families and 43 per cent suffered from Dupuytren's contraction. Since the disease commonly manifests itself late in life, this figure was considered explicable in comparison with the expected 50 per cent in dominant hereditary conditions.

Particular difficulties arise in the analysis of the hereditary character of this disease, since it usually only appears at a relatively high age. It is thus more than usually difficult to obtain material, and that available is difficult to interpret. The more extensive

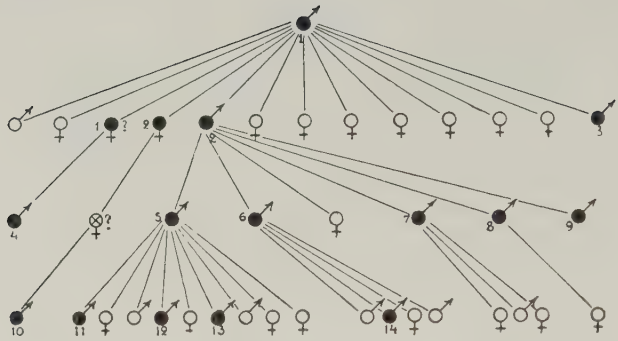


Fig. 37. Occurrence of Dupuytren's contraction in a family reported by Krogius (1921). ⊗ died young and was assumed to be a carrier.

pedigrees given by some workers are thus valuable, even if it must be assumed that they are more or less selective, since only families with a large number of cases were reported. Backman and Sprogis (1925) traced the deformity through three generations, and found 17 cases with three, eight and six cases in the respective generations among 53 persons examined. It is noteworthy that they, as did Kartschikjan (1927), considered that the disease was probably recessively hereditary. Krogius (1921) see Fig. 37, Löwy (1923), Apert (1925), Miskolczy (1929), Stackebrandt (1932) and Schröder (1934) reported families in which the disease occurred in four successive generations, and Debrunner (1935) investigated seven cases with Dupuytren's contraction out of eight, representing five generations of one family. In all these cases reported, the disease was considered to be dominantly hereditary. Moreover, it was evident in some cases that the disease did not occur in the women, although it could be assumed that they were carriers (Fig. 37).

Light was also thrown on the heredity of the disease by Jentsch (1937), and Couch (1938), who described it in monozygotic twins. The latter called his cases "identical Dupuytren's contraction in identical twins," whereas those reported by Jentsch showed considerable differences. Then Bergh (1939) investigated 151 pairs of twins with regard to diabetes and found three pairs suffering from Dupuytren's contraction. In both pairs of monozygotic twins the disease showed great similarity in each pair.

The occurrence of Dupuytren's contraction in some families coincident with other hereditary diseases, for example imbecility (Backman and Sprogis), Friedreich's hereditary ataxia (Orbán 1930), congenital luxation of the hip joint (Debrunner) does not justify the assumption of a hereditary connexion with these diseases.

It does not appear from the literature that the hereditary character of this hand deformity is as yet clear. A number of authors assume dominance and others recessivity. It is evident that it cannot be a question of regular dominance. The question is whether there is, in fact, hereditary dominance with varying penetrability, or whether the heredity is recessive. The former alternative appears to be most probable. The fact that the disease is so much more common in men than in women is a possible indication that the heredity is of a sex-linked character.

2. The Writer's Investigations

In the writer's material, comprising 50 patients, the disease was stated to have occurred in the family in no less than 22 cases (44 per cent). According to the literature referred to above, this is, together with Schröder's cases, the highest frequency reported. This can perhaps be explained by the fact that the patients were requested to make inquiries before they made their statements. Thus several patients, who were not previously aware of similar cases in their family, were able to give positive statements. In a number of cases, however, the patients made no careful inquiries, and in several there were few or no near relations alive. It must also be taken into account that the majority of early cases are overlooked by the layman, and also that a number of persons with predisposition for the disease were at an age when it had not yet become manifest. All these factors contribute to giving too low a figure.

As it was pointed out in the survey of the literature, statistics of this kind are limited in value, since they depend both on how many branches of the family are investigated and how many of the family in question are alive.

It is more interesting to investigate how often the disease occurs in particular groups of relations, for example in parents or siblings. It is evident that since the disease usually only appears at a late age, it is difficult to obtain statements concerning siblings, since

many have not reached the age at which the disease makes its appearance. Only in five cases were there statements that siblings were affected. Statistics regarding parents are of greater value. Eleven out of 50 fathers (22 per cent) suffered from the disease. There was only one case (2 per cent) among the mothers.

Even in large families — one patient had eight siblings — there were only a few cases of finger contraction. In addition, however, to the material described here, in which all the patients underwent operation, the writer knows of one family in which five out of eight brothers suffered from Dupuytren's contraction, and another in which all three brothers were affected.

Since the disease is relatively uncommon, the figures obtained can be considered to depend on dominance with low penetrability. The low frequency amongst the mothers can either depend on environmental factors such as heavy work or — more probably — that the disease is to a certain extent sex-linked. It is not, of course, necessary to assume that the disease is inherited in the same way in all families. It is possible that the heredity is at times dominant, at times recessive, and at times more deviating from the usual manner. It was not possible to obtain sufficient data for other groups of relations than those mentioned above, and no definite conclusions can therefore be drawn in these respects.

The patients often stated that their hands were exactly like those of other members of the family. Since in Dupuytren's contraction the ring or little finger is flexed in the majority of cases (cf. Table 5, p. 31), such a statement is not surprising although a number of writers attach importance to it (Vizioli 1886, Löwensberg 1906, and others). The index fingers of one of the patients in the present material were most affected, as were those of his mother. Another reported that two of his first cousins, one male and one female, suffered from contraction of their middle fingers, as did the patient himself. Even though this more unusual manifestation of the disease occurred in several cases, it does not justify the conclusion that certain types of Dupuytren's contraction have a familial occurrence, although the observation might suggest such a possibility. It is interesting to note that in those cases in which the index fingers were involved, a maternal grandfather suffered from flexion of the two ulnar fingers only.

II. THEORIES REGARDING THE AETIOLOGY OF DUPUYTREN'S CONTRACTION

1. Survey of the Literature

No complete critical survey has yet been made of the various theories which have been advanced to explain the aetiology of Dupuytren's contraction.

The writer has considered it worth-while to try to bring together these theories, and to compare them with the results of his own investigations. The vast bulk of the literature on the subject makes it not ideally suited for this type of treatment, since it ranges over a very wide field, and since many of the theories are complex and do not lend themselves to general treatment. From the practical point of view, however, it is felt that the general study of the disease will be simplified by this procedure and that the division of the material as made by the writer, though in certain cases open to dispute, is nevertheless justified.

A. Trauma

a. *Occupational Trauma.* Cooper (1822) and Dupuytren (1832), who first pointed out the true nature of this disease as a contraction of the palmar aponeurosis, both attributed it to manual labour. Thus the classical cases of Dupuytren, the wine-merchant and coachman, "were obliged, the one to perforate continually the casks with a gimlet, the other to ply his whip unceasingly on the back of his jaded horses." There was no lack of opposition to this theory, but for a long time many authorities (Chelius 1843, Dieffenbach 1845, and others) believed that the contraction was provoked by pressure and friction on the palmar aponeurosis in different occupations. The fact that the deformity is often seen in people who have not used their hands for any kind of rough work was later considered by the majority of writers to be incompatible with this theory, although a few in various countries continued to support it (Rémy 1877, Humphrey 1884, Durel 1888, Masciotra 1925, Bejul 1926, Becker 1941, Palmer and Southworth 1945, etc.).

Dupuytren also incidentally mentioned predisposition to the disease and later on, when the condition was generally ascribed to a constitutional origin, some investigators combined these two theories. Chronic trauma in conjunction with *cold* was thought by Schlack (1942) to have contributed to the increase of this disease in military working parties during the cold winters of the recent war. He did not, however, give any statistics.

Research on this problem was made by HEUSER (1904) who examined 255 working-class persons of varying ages. He found definite changes in the aponeurosis in no less than 16.8 per cent and 7.8 per cent suffered from contraction. He was of the opinion that persons doing lighter work were less liable to the disease. Unfortunately he did not publish any comparative material. The first more extensive investigation into the significance of occupation in the causation of this disease was made in England as the result of a report from Factory Inspectors by COLLIS and EATOCK, medical officers of Health in Nottingham, on the prevalence of Dupuytren's contraction among lace machine "minders" or "twisthands," whose work entailed continued trauma to the palms. Their inquiry showed that among 1,360 lace minders 13.1 per cent had been found with Dupuytren's contraction. Before a Departmental Committee set up in 1912 to examine the claim, different opinions were expressed about these findings. SIR ROBERT JONES, a medical witness, was of the opinion that the cause was probably a predisposition in an individual, with palmar irritation as the exciting cause. COLLIS thought that palmar stresses or strains were the exciting causes in all cases. BLACK (1915), however, in 1,329 lace minders examined, only found an incidence of 1.7 per cent and thought the discrepancy between these percentages might be accounted for by the committee having visited a larger number of the small factories where most of the older men were to be found. He did not believe that the disease was more common in the working-class than in any other. Neither did ROSENBURG (1925) who made an inquiry among medical officers about miners and dock-workers, etc. Without information concerning the ages, these investigations do not allow of any definite conclusion.

But there are investigations which definitely indicate that repeated trauma to the palm in certain occupations might predispose to this deformity of the hand.

Thus the series in Table 10 A show that NIEDERLAND (1933) in Vienna found an exceptional incidence among textile workers on special work in which the palmar aponeurosis was constantly strained, and so did SCHRÖDER (1934) who re-examined some of the workers NIEDERLAND had investigated, as well as some younger ones. The influence of occupational trauma is demonstrated in both these series and differences in the frequency of occurrence might be due to the lower average age in group III of NIEDERLAND's material.

The influence of the occupation and age can be seen in GERRITZEN's two series (1936) in the same Table. In one of the series, persons under the age of 40 were excluded. GERRITZEN held the opinion that, compared with the age, the occupation was of very little importance. It is difficult in making an assessment to separate these two factors, but LUND's

Table 10 A

Frequency of Dupuytren's Contraction in Men in Relation to Age and Manual Work

Author	Age	Total number of cases	I Light or no manual work		II Heavy and medium heavy manual work		III Very heavy manual work	
			Cases	Percentage of D. C.	Cases	Percentage of D. C.	Cases	Percentage of D. C.
Niederland (1933)	>40	589	112	0.9±0.9	342	4.7±1.1	135 a)	17.8±3.3
Schröder (1934)	40—90 b)	2198	350	1.4±0.6	1700	6.3±0.6	148 a)	8.8±2.3
Gerritzen (1936)	all ages	1200	180	4.4±1.5	1020	6.4±0.8	—	—
» »	>40	543	75	9.3±3.4	468	12.8±1.5	—	—
Vigdortschik cited by Deckner (1938)	—	265	—	—	—	—	265 c)	9.4±1.8

a) »Lüstrierer» — dyers of special yarn, who raise weights of 25—30 kg by a jerking motion 540- 600 times during an 8-hour shift

b) Group III includes cases from 30 years of age.

c) Brewery workers.

Table 10 B

*Frequency of Dupuytren's Contraction According to Age Among Brewery Workers** (Lund *1941*)

Age	Number	Percentage frequency
<30	157	—
30—39	265	3.8±1.2
40—49	347	9.8±1.6
50—59	165	10.3±2.4
>60	87	25.3±4.7
All ages (Mean = 43.2)	1,021	8.1±0.9

* Belonging to Group III, Table 10 A; majority employed in handling 42 kg cases of beer.

Standard errors in Tables 10 A and B calculated by the writer.

series (Table 10 B) certainly gives a very high incidence of Dupuytren's contraction in elderly brewery workers as compared with that in people of a similar age engaged in other occupations. The figures in Table 10 A will be discussed further later in this paper. (The importance of constant injury was also stressed by Koelsch 1935, Maurer 1936, Teleky 1939, and others.)

Referring to his own investigations, Niederland expressed the opinion that Dupuytren's contraction is to be regarded as an occupational disease in the majority of cases. Schröder considered, however, that in claims for compensation this contraction should not be classed as a true occupational disease, but that it should give the right to compensation only in such cases in which it developed following heavy manual labour during several decades. He thought that it was probable that the disease would remain latent where there was only a slight predisposition to it, unless trauma had occurred during work. This opinion was shared by David (1935) as regards such cases in which the disease had not a familial occurrence.

According to Després (1880), Sovetov (1931) and Schröder, persons with incipient contraction or familial tendency to the disease should be advised to refrain from work that placed a strain on the hands. As a basis for a law on Dupuytren's contraction as an occupational disease, Teleky suggested that this should only apply to certain occupations and to men over 40 years of age who had been employed for a minimum of 10 years.

According to Baader (1933) the disease is a notifiable disease in Holland. In Russia, since 1931, persons suffering from Dupuytren's con-

traction are entitled to compensation when the disease had arisen in connexion with their occupation. In Germany the disease has been the subject of considerable interest from the point of view of industrial medicine.

The majority of authors (Macaggi 1933, Gerritzen 1936, Smith and Masters 1939, etc.) deny, however, the importance of trauma in the appearance and development of the disease. In view of the fact that only a certain number of persons in various occupations develop the disease, although their hands are not exposed to more trauma than those of others, it is evident that trauma cannot be the decisive factor in the aetiology of the contraction. This does not, naturally, exclude the possibility that it can be a contributory cause. This question will be discussed further on p. 130.

b. ***Single Injury.*** A single definite injury to the palm has been considered the cause in many recorded cases. For instance, Smith (1885) attributed the contraction to local injury in two of his 70 cases. The palmar thickening was exactly similar in appearance to his other 68 cases. In 50 cases described by Nichols (1899) two developed contraction after lacerated wounds and two cases were attributed to a strain or wrench of the hands. Examples of such observations could be multiplied (Lockwood 1886, Kisgen 1889, Russ 1908, Wendenburg 1913, Horák 1914, etc.).

In order to establish that a patient contracted this disease as a result of an accident, Rosenburg considered it requisite that there should be a connecting factor between the accident and the disease. The bilateral character of the process and the nature of the injury should also be given careful consideration.

Two cases reported by Kaern (1912), both developed following infected wounds of the palm. The condition was described as *similar to Dupuytren's contraction*, and was entirely cured by excision of the scar tissue. It is beyond doubt that Wyss (1909) was mistaken in his diagnosis of this disease in a boy, who developed retraction of the scar following a superficial lacerated wound. Normal function was later restored by physiotherapy; and in Roth's case (1920) there was a septic fibrosis. These cases are instructive and underline the necessity of accurate diagnosis in cases of this type. Though there undoubtedly are cases where the contraction starts after a single injury and the process is seen to spread from the scar, such sequelae to injuries of the hand are rare.

Merker (1897), Marwedel (1927) and others considered that a single blunt injury was the cause of contraction. Their patients developed contraction of the fingers a few weeks after the accident.

But there are quite as many writers on this subject who deny the influence of a single trauma (Niehus 1927, Schröder 1934, etc.). This question will be discussed later.

c. *Fracture of an Upper Extremity.* Another interesting group of cases can be assembled from the literature, i. e. those in which the disease made its appearance following a fracture of one of the upper extremities.

Such cases were described by Babinski (1886), Rinne (1888), Féré and Demanche (1903), Scholle (1930), and others. In the majority of cases a fracture of the radius was involved. The phenomenon was interpreted as a trophic disturbance caused by injury to the nerves (Iversen 1909) or as a reflected effect, caused by the fracture, on the innervation of the vessels thus bringing about thickening and hardening of the aponeurosis (Schaefer 1936). From larger series we can mention that two of Nichols (1899) 50 patients had old fractures of the forearm of the affected hand. In 200 cases collected by Maurer (1936) 24 had substained fractures of the arms or luxations of the shoulders, but in 12 cases only was the contraction confined to the injured side. In other series, however, we seldom find statements of fractures prior to the contraction. An investigation by Kohlmayer (1935) showed that Dupuytren's contraction developed following a fracture of the radius in 5.4 per cent of 110 men and in 0.75 per cent of 530 women. These frequency figures are not remarkably high and do not, without further investigation, permit us to draw the conclusion that contraction was a sequel of the fracture. Moreover, in two of the men the contraction of the fingers was bilateral, whereas the injury was unilateral.

There is very little cause to assume that fracture plays any considerable rôle in the aetiology.

B. Neuropathy

A number of the theories which occur in the literature concerning the neurological origin of Dupuytren's contraction are theoretical speculations only, while others have been founded on insufficient material. Since, however, a number of them have become widespread, a short survey is justified.

In the majority of theories on the cause of Dupuytren's contraction, emphasis is laid on some particular part of the nervous system. It is therefore convenient in considering these theories to classify them according to that part of the nervous system suggested, although

in some of the more complex theories there are certain difficulties in adapting the method. Cases in which the disease was ascribed to neuroluetic factors are considered in a special group, as were those combined with epilepsy (Chapter VI).

a. *Peripheral Nerve Lesions.* The fact that the majority of cases of Dupuytren's contraction are localized to the palmar distribution of the ulnar nerve and that this nerve, through its position at the elbow joint, is easily exposed to injury, has caused numerous speculations regarding lesion to the ulnar nerve as a cause of the contraction.

Eulenburg (1883) was the first to follow up this line in the neuropathogenetic discussion. In one case he considered that the contraction was a trophic disturbance resulting from bilateral ulnar neuritis. Guinebault (1897) thought that an arthritic diathesis predisposed to this neuropathy. Schäffer (1902) described a curious case in which finger contraction on the right side developed four months after luxation of the shoulder joint with rupture of the biceps and subsequent ulnar neuritis. Nineteen years later exactly the same chain of circumstances occurred on the left side and was followed by contraction of the fingers. The course on both sides was so similar that it was easy to presume a causal connexion. Reichel (1917, 1925) published accounts of altogether 7 cases in which the disease developed after accidental injury to the ulnar nerve. He believed in a neuropathic influence arising from some lesion of this nerve. This theory was later accepted by the majority of workers who gave accounts of a few similar observations (Coenen 1918, Laignel and Nogues 1918, Schubert 1922, Noica and Parvulesco 1932, Wolf 1935, and others).

In opposition to these neuropathic theories we have statistics from World War I collected by Walter (1920). These do not show a single case of Dupuytren's contraction in 37 cases of injuries of the ulnar nerve. Moreover, nerve injuries are seldom reported in large materials dealing with Dupuytren's contraction.

Abbé (1888) put forward a more complicated theory. This was that slight injury to the palm caused an impression on the spinal cord. The latter created a reflex influence on the part originally injured, thus producing vascular and nutritive tissue disturbances. A second set of reflex symptoms, as well as a reflection of the disturbance to the corresponding part of the opposite hand then developed, caused by the contraction. Alajouanine et al. (1930) gave a similar explanation of a bilateral contraction which developed following a unilateral nerve injury

in the form of ascending neuritis. This gave rise to a lesion of the spinal cord with bilateral trophic symptoms. Ballif et al. (1936) interpreted a rapidly developing contraction of both the palmar and plantar aponeuroses in a woman as a result of a severe polyneuritis. Merle (1909) expressed a vague theory that Recklinghausen's neurofibromatosis was the cause of bilateral Dupuytren's contraction in one case.

In this connexion we can also mention the group described of cases observed after a fracture of the arm.

b. *Spinal Cord Lesions.* Proceeding from the theory that Dupuytren's contraction is the expression of a trophic disturbance and from the fact that the disease occurs symmetrically, a number of writers localize the primary cause to the central nervous system.

Oppenheim (1894) stated that spinal gliosis was the cause in two cases. Bieganski (1895) described the first case of Dupuytren's contraction with syringomyelia in the cervical region. This spinal cord lesion which is characterized, amongst other symptoms, by trophic disturbances, aroused particular interest in several authors. Thus a similar coincidence was described by Neutra (1901), Schlesinger (1901), Perrero (1905), Roussy et al. (1932), and others. Urechia and Dragomir were able in 1935 to collect 20 such cases. Particular attention has been drawn to the fact that Testi (1905, 1906) observed this combination of diseases in three brothers. This does not, of course, prove a relation between the diseases. (A familial occurrence of Dupuytren's contraction with the same frequency as Testi's material, but without accompanying symptoms from the nervous system has already been reported by the present writer.)

Trauma to the lower cervical region of the spinal cord was assumed to be the cause of the finger contraction in individual cases by, amongst others, Caspari (1896), Mainzer (1905), Dejerine (1914). Finally, it can be mentioned that a lesion of the spinal cord as a result of pellagra was assumed to be the cause of Dupuytren's contraction by Parhon and Goldstein (1902, 1905) and as a result of spinal leptomeningitis in another case, Licciardi (1907).

c. *Cerebral Lesions.* Lesions to the cerebral trophic centres have also been suspected of causing contraction. Mauclaire (1913), for example, reported a case of bilateral Dupuytren's contraction in which retraction diminished on the paralyzed side following cerebral haemorrhage. A similar strange observation was made by Lange (1885). The suspicion that both these cases were manifestations of paralytic phenomena immediately arises. An assumption made by Braam-Houckgeest (1923) that the cause of the contraction was to be found in the

central ganglia of an elderly man and his two sons — since they all showed neurological symptoms, although entirely different in character — appears to be equally unreasonable.

d. *Disturbances of the Sympathetic Nervous System.* It has already been pointed out that when the cause of the contraction is ascribed to the central nervous system, some disturbance to the trophic centres has been assumed. An origin in the peripheral sympathetic nervous system has, however, also been suspected.

Nippert (1929) regarded the contraction as a symptom of hypertonicity of the autonomic nervous system and thought that it is inherited; and Powers (1934) reported 29 cases and believed that in the presence of visceral or pulmonary disease the sympathetic ganglia were irritated, resulting in hypertrophic and dystrophic changes in the periphery, among which is Dupuytren's contraction which he regarded as often an important diagnostic sign. Kehl (1943) presenting six cases of Dupuytren's contraction, regarded as a sequel to coronary occlusion, also thought irritation of the sympathetic ganglia might play an important aetiological rôle. Lechelle et al. (1927), Weill and Maire (1934), Powers, and others, associated Dupuytren's contraction with scleroderma, a syndrome which they interpreted as an expression of a disturbance of the sympathetic nervous system. Several of their cases (as did one of Deckner's 1938) also manifested Raynaud's phenomenon. Wolf (1935) made a one-sided survey of these problems, and came to the conclusion that the contraction was a general symptom of a disturbance of the central or peripheral trophic nervous system, comparable with Babinski's reflex in lesions of the pyramidal tract.

e. *Neurosyphilis.* Of the organic nervous diseases, neurosyphilis has already been mentioned in a few cases as a cause of Dupuytren's contraction. The question whether tertiary syphilis did not play a prominent rôle in the causation of the deformity was raised by Hedges (1896). Improvement of the finger contraction observed after antiluetic therapy has also been cited in support of such an opinion (Silva 1924, Koster 1935, and others).

Senator (1898) pointed out that the process had many characteristics analogous to those of tabetic arthropathy as a chronic deforming process in the joints of the extremities with a painless course. Neutra (1903) even interpreted the contraction in two cases as an early symptom of tabes.

Dupuytren's contraction in general paralysis was reported by Régis (1887), Löwensberg (1906), and others. Féré and Francillon (1902) found a simultaneous appearance of these two conditions in 2 cases out of 38. This is, however, a lower frequency than that found by

them in other psychic diseases of 14 out of 226. Tichet considered in his treatise in 1904 that it was possible to assert that the diseases were independent of each other, since only 3 cases of finger contraction were found in 1,120 cases of general paralysis.

It can be seen from the literature that the neurogenic theories are, to a great extent, based on coincidences in individual cases and this fact does not, naturally, give any definite information on the subject. Moreover, larger series of Dupuytren's contraction do not support these assumptions. It appears plausible that trophic disturbances, which affect the entire hand, would also affect the aponeurotic tissue and influence the physico-chemical properties of the connective tissue. Nevertheless, the majority of cases of Dupuytren's contraction certainly appear independent of organic nervous diseases.

C. Gout and Rheumatism

Already before the days of Dupuytren the characteristic finger contraction had been attributed by Chomel (1813) and others to a *rheumatismal affection or to gout.* In France this view was maintained by Menjaud (1861), Pozzi (1877), but Houel (1877) opposed it on the grounds that in about 20 cases he had failed to find either affections of the joints or tophi. In America, Keen in 1881 reported 95 cases, with a family history of gout or rheumatism in 64, and he thought the contraction to be of a constitutional origin, and this he stated to be as a rule gout or rheumatism. In England the same view was held by Reeves (1881) and by Hedges (1896), who found the same coincidence in 39 cases out of 60.

a. ***Gout.*** Gout only as the cause of Dupuytren's contraction has been the opinion of several leading writers on this subject. Adams (1878, 1890) thought the deformity was due to gouty thickening of the palmar fasciae, and according to Vogt (1881) this coincidence was beyond doubt. When there was a hereditary tendency, Daeschler (1903) believed that this was a gouty diathesis. Gemmel (1899) regarded the symmetrical appearance in the hands as pathognomonic for a gouty origin, but in 300 patients with gout he noticed only 3 contractions of the palmar fascia.

The incidence of gout in cases of Dupuytren's contraction varies, as will be seen from the literature:

Costilhes	(1885) —	86	cases,	6	with	gout
Anderson	(1897) —	39	»	1	»	»
Daeschler	(1903) —	18	»	4	»	»
Maurer	(1936) —	200	»	12	»	»

These statistics imply no relation between the two illnesses, nor is the fact that Reeves and others reported cases on which they had operated and which were followed by an acute attack of gout any proof of such an assumption.

It was generally believed that the nodules in the aponeurosis corresponded to a gouty deposit which became fibrous. There is, however, only one case described where the palmar fascia was impregnated with crystals of urate of sodium (Lockwood 1886). In this case there were also deposits in the dorsal fascia and a gouty arthritis of the finger joints; the specimen was designated "gouty contraction of the palmar fascia" and not Dupuytren's contraction, as in another case without deposits reported in the same article. Later writers have referred to the findings of Lockwood, giving them a significance which, in fact, they do not possess.

Nowadays this theory has few adherents; it was even rejected long ago (Smith 1885, Abbé 1888, and others). On the other hand, Moser (1936) again raised the theory of a connexion between the two conditions, when he himself developed Dupuytren's contraction and also suffered from gout.

At the date when the gout theory was favoured, "gout was supposed to be at the bottom of every aberration from health." Furthermore, gout was often confused with various forms of arthritis, which partly explains the fact that several reports appeared on the frequently noticed retraction of the palmar aponeurosis in "gouty" subjects by contemporary writers. Clinically, the symptoms are entirely different and available information gives no support for the theory of a gouty origin of Dupuytren's contraction. Furthermore, it is evident that gouty patients do not develop the disease more frequently than others, and it is significant that this assumed connexion is not mentioned in any of the authoritative works on gout (Minkowski 1903, etc.).

b. ***Rheumatism.*** Single cases are reported in which the deformity began during or following an attack of acute rheumatism, Keen (1882), Byford (1921), Londres et al. (1937). The frequent simultaneous occurrence of Dupuytren's contraction and the vague conception "rheumatism" together with the difficulty of adequately explaining the cause of either, has led to the suggestion that this is no coincidence by mere chance.

The following statistics from the literature are of interest:

Costilhes (1885) — 86 cases of DC, 17 with rheumatic diathesis
Durel (1888) — 12 » » » 9 » » »

Anderson	(1897) —	39	cases	of	DC,	10	with	rheumatic	diathesis
Nichols	(1899) —	50	»	»	»	42	»	»	»
Byford	(1921) —	38	»	»	»	23	»	»	»
Maurer	(1936) —	200	»	»	»	49	»	»	»

In eight cases of Byford's series, rheumatism appeared, on an average, 11.3 years after contraction and twelve cases had rheumatism with an average of 14.8 years before the contraction.

A number of the authors mentioned above, as well as Prîbram (1903), and others, nevertheless only ascribed some of the cases of retraction of the palmar aponeurosis to rheumatism.

Since rheumatism is now often regarded to be due to a focal infection, the association of it with Dupuytren's contraction first made Byford suggest the possibility that the contraction was the result of bacterial action in some remote part of the body; in 38 cases he demonstrated a source of infection present in all but one. The most common location of this focal infection was in the teeth. Meyerding (1936) found the incidence of known focal infection in 141 out of 273 cases high enough to be of some significance as an aetiological factor, and Gill in the discussion that followed this report declared that he was convinced that in many cases Dupuytren's contraction was due to focal infection, and mentioned several cases in which the contraction ceased to progress on removal of these foci. Tubby (1923) regarded the nodes in the fasciae of the back in fibrositis, and rheumatic nodes as "a somewhat similar condition to Dupuytren's contraction", and suggested the possibility of finger contraction being a *fibrositis*.

The investigations concerning the importance of "rheumatism" in this connexion referred to above lack proof. This is partly because accurate data is usually lacking and partly because no comparisons were made with satisfactory controls. An indication of the inaccuracy of the assumption is found in the lack of conformity between the series given by the various workers.

Statements concerning Dupuytren's contraction in chronic polyarthritis, particularly in elderly women (Labbé et al. 1934, etc.), must certainly be accepted with considerable reserve. This has already been pointed out in the discussion on differential diagnosis.

Costilhes (1885) stated that in his series of 86 cases with finger contraction, 14 suffered from arthritis deformans. Ledderhose (1897) was convinced that a patient with symptoms of arthritis deformans in any of the large joints or in the spine would also show characteristic changes in the palmar aponeurosis, since he had observed this coincidence in several hundred cases. It is, however, questionable

whether the thickening of the fasciae without nodules, which he called fasciitis palmaris, should be regarded as genuine Dupuytren's contraction. No later worker shared his opinion.

It should also be emphasized that any summarily selected disease connected with old age would show a marked coincidence with Dupuytren's contraction, since the frequency of this condition increases with increasing age.

D. Endocrinopathy

von Gaza (1925) pointed out that Dupuytren's contraction belongs to those diseases which run parallel to an aging of the connective tissue. He considered that these are dependent on the function of the glands of internal secretion. As a rule, however, theories of this type have ascribed the contraction to a specific endocrine disturbance.

a. ***Diabetes.*** Several writers have reported Dupuytren's contraction in conjunction with diabetes. Cayla (1883) and Viger (1883) reported six such cases, all aged 56—72 years, as well as one case with polyuria without diabetes. Maréchal (1899) mentioned two cases and regarded the deformity as a sign of diabetic trophoneurosis. Nichols (1899) in 50 patients with Dupuytren's contraction found two cases of glycosuria, Davis and Finesilver (1932) in 40 cases found a number of four diabetics and Maurer (1936) in 200 patients found three with coincident diabetes. Durel (1888) 12 cases, Deckner (1938) 60 cases, etc., found, however, no diabetics in their series.

A correlation was also thought probable by Teschenmacher (1904), who found the conditions associated in 33 cases out of 213 diabetics, but it is worth noticing that they were 50—70 years of age. He also mentioned that von Noorden only met with four cases in 800 diabetics. Davis' and Finesilver's list of 200 diabetic patients included six cases of Dupuytren's contraction, and they thought the condition occurs more frequently in diabetic persons than in those with other diseases, as only seven cases were found in 641 persons of the latter group of approximately the same age. A noteworthy finding was made by Schlosser (1932) who stated that in a 45-year-old man suffering from Dupuytren's contraction, the thickening of the palmar aponeurosis entirely disappeared within three months following rational treatment of his diabetes.

Compared with the general frequency statistics for Dupuytren's contraction given in Chapter II, the figures for diabetics are not remarkable. Then Bergh's (1939) genetical and biological study of 151 pairs

of twins with regard to diabetes also gainsays the theory that diabetes could be an aetiological factor in the development of the contraction. Two pairs of monozygotic twins in his material showed Dupuytren's contraction. In one pair, only one twin suffered from diabetes. In the other pair, one twin was well compensated by means of diet and insulin, whereas the other was in poor condition owing to constant neglect of his diabetes.

In view of the aforementioned facts, we can assume that diabetes is of little practical significance as a cause of Dupuytren's contraction.

Wagner et al. (1942) saw one case of Dupuytren's contraction among 100 diabetic boys and two cases among 100 diabetic girls. They classified this symptom among more or less specific signs, as there was no case in the non-diabetic group. They described Dupuytren's contraction as an isolated contraction of the fifth finger, but did not say how this differed from a symptom they called "curved fifth finger." Until further details are given, care must be taken about drawing any conclusion from their report in this respect.

b. ***Thyroid Deficiency.*** Léopold-Lévi (1913) who believed that retraction of the palmar aponeurosis was a symptom of thyroid deficiency, tried prolonged internal treatment with thyroid extracts in seven cases, with favourable results in five. Wainwright (1926) also had excellent results in four cases of Dupuytren's contraction from the administration of thyroid extracts for years.

These noteworthy results have never been confirmed on a larger scale.

c. ***Parathyroid Deficiency.*** A theory that dysfunction of the parathyroids is the possible (or even the usual) cause of Dupuytren's contraction was presented by Leriche and Jung (1930). They described two cases with a hypocalcaemia of about 7 mg serum calcium/100 ml. Both were successfully treated with parathyroid extract. The first case had developed tetany after partial removal of the thyroid, and retraction was reported as almost disappeared after a few weeks' treatment. The reason for hypocalcaemia in the second case was unknown, and treatment was said to give improvement. The above authors referred to the relation of hypocalcaemia with scleroderma affecting the connective and elastic tissues. Their description of the finger contraction does not allow us to judge to what degree the tetany symptoms were superimposed. Their hypothesis was not confirmed later, either by them (Leriche 1947) or by other writers.

Hugonot and Friess (1932) assumed, on insufficient grounds, in a case of ulcus ventriculi together with Dupuytren's contraction, that these conditions were dependent on a lowered calcium level in the blood. Labbé et al. (1934) certainly believed that the cause of contraction was

disturbance in the calcium metabolism. The case cited was associated with hypercalcaemia, and the contraction was said to decrease when the calcium level fell below normal.

These investigations alone are not by any means sufficient to warrant the assumption that disturbed function of the parathyroids is the cause of Dupuytren's contraction.

d. *Pituitary Deficiency.* Fründ (1926) described four cases with peculiar contractions of the fingers and toes. Two had contractions in the hip and knee joints as well, and another showed a clinical picture resembling scleroderma. X-ray examination revealed definite reduction of the pituitary fossa in all the cases. Pituitary therapy was followed by an improvement. Although Dupuytren's contraction was not present in the cases reported, a hypophyseal connexion with this disease in the above cases was later assumed by some writers. Oehlecker (1930 b) examined a number of patients with Dupuytren's contraction with a view to this theory, but in none of the cases did he find any abnormalities of the pituitary fossa.

E. Developmental Theories

Riedinger (1898) can be regarded as a pioneer in this field. He described a rare case with islets of cartilage and bone in the plantar aponeuroses. He believed that these had developed from accessory nuclei of the skeleton. On these grounds he advanced a hypothesis that Dupuytren's contraction was connected with similar atavistic phenomena. As late as 1935, Coenen supported this opinion in an account of benign finger tumours. Already in 1889, Koenig had speculated whether the contraction did not depend on a congenital disposition to the formation of fibroma in the palmar aponeurosis.

Kajava (1917) reported the results of a comparative anatomical investigation of the superficial flexores breves muscles of the hand. These muscles are present in considerable variations in the lower mammals, but are lacking in the anthropoid apes and in man. Kajava interpreted the palmaris brevis muscle in man as a rudiment of these muscles. Gräfenberg (1905) had, however, stated that a flexor brevis superficialis manus muscle is found in the embryo as a powerful muscle even in man, but later merges with the flexor digitorum sublimis muscle.

On the basis of Kajava's investigation, Krogius in Finland (1921) brought forward the theory that the atavistic remains of the flexores breves manus muscles were the cause of Dupuytren's contraction, and that this muscular tissue gradually underwent a tendinous degeneration.

He considered that a number of features in the clinical picture could be explained "*if* the palmar aponeurosis can be regarded as deriving from the superficial muscle layer in the vola manus." He nevertheless pointed out that little was known of the ontogeny of the palmar aponeurosis and that he himself had not carried out any investigation into its embryological development. He did, however, claim to have observed islets of striated muscle tissue in the aponeurosis of newborn infants. Similar findings have not been reported by other writers. Krogius did not mention the method of examination used by him; furthermore, the aponeurosis is close to striated muscles in several places. It is therefore possible that an incorrect interpretation of individual microscopic sections can explain this somewhat surprising statement.

Krogius's theory of the importance of developmental disorder as the primary cause of the condition has been referred to more or less critically in the majority of papers on the subject. In Germany, particularly, it was widely accepted: Miskolczy (1929), Oehlecker (1930), Schröder (1934), etc., and Serstov (1928) in Russia also supported it. The retracted tissue was interpreted as a reaction of the congenital connective tissue hyperplasia brought about by irritations occurring during the course of years. Deckner developed this hypothesis further in 1938, as well as in earlier publications. He also described cords in the altered aponeurosis, which showed histologically a striation reminiscent of that of the muscle fibres (!) and interpreted them as a faulty differentiation of tissue into something between muscular and tendinous tissue. These observations have never been substantiated.

Krogius's theory will be discussed in connexion with the present writer's observations (p. 134).

F. Contraction of the Palmaris Longus Muscle

In 45 cases of Dupuytren's contraction, Smith (1885) found the tendon of the palmaris longus muscle tense and prominent in nearly every case examined, and it was thought that this might indicate the primary cause of contraction. He thought section of the palmaris longus tendon might be beneficial in the early stages of contraction. Fischer (1885), Myrtle (1885), and others never found the palmaris longus muscle in an abnormal condition nor did Nichols (1899), who examined 39 cases with reference to this point.

G. Local Infection

Anderson (1897) considered the condition to be an inflammatory hyperplasia commencing in the skin and subcutaneous tissue of the palm, involving the fascia secondarily. He pointed out that the seat of the initial lesion is situated where the finger-tips come in contact

with the palm, and believed in the agency of a specific micro-organism which gains access to the palm of the hand by slight trauma of the epidermis caused by the finger-nails. The only evidence he brought forward was the growth of a yellow nodule on agar, but culture tests and microscopical investigations gave negative results so far as finding the germ was concerned. No statements have later appeared substantiating this theory, though this point has been examined by different investigators (Beddoes 1928, and others). Evidence in favour of bacillary infection as the cause of the disease is thus lacking.

Tubby (1923) noticed at the onset small atrophic spots in the skin and thought this might be an indication of changes in the sweat glands associated with the absorption of some local septic material. But in the microscopical specimens he was not able to find evidences of such a process.

H. Tuberculosis

Poncet (1909) classified retraction of the palmar aponeurosis among "les lésions paratuberculeuses" and considered that it could be the first sign of a tubercular infection. His pupils (Perdrizet 1904, and others) described cases in which they were of the opinion that the fibrous tissue reaction was caused by toxins from tuberculous processes in other organs. This theory — like that of Poncet concerning "le rhumatisme articulaire tuberculeux" — caused considerable discussion. Lack of conclusive clinical evidence gives it, however, no interest nowadays.

As a curiosity, we can mention Exner's case (1921) of pulmonary tuberculosis with contraction of the fingers, in which the excised aponeurosis contained tuberculous granulation tissue.

Schaumann (1938, 1944) saw two of his patients with lupus erythematosis develop Dupuytren's contraction and regarded this deformity as well as cirrhosis hepatis and polyarthritis as equivalents of the skin disease, and as symptoms of a condition he termed lymphogranulomatosis metascrophulosa. Though he pointed out that these two cases were not enough to prove any causal connexion he found the theory supported by histological examinations.

I. Chronic Intoxication

Costilhes (1885), in 5 cases of 86, attributed a great deal of importance to lead poisoning in the causation of Dupuytren's contraction, as did Daeschler (1903) in two cases. In Hedges (1896) 62 cases, there were six instances of painters and printers. Their occupation puts them much in contact with lead, and he thought this might be significant, "as lead is very apt to bring out gout where one is predisposed to it."

In 33 patients with this contraction, Michaux et al. (1925) found

that 24 had been exposed to lead poisoning and 13 had signs of intoxication. The degree of poisoning and of the contraction seemed to run parallel. In all cases of Dupuytren's contraction they regarded the hand deformity as much a sign of lead poisoning as the classical signs! These remarkable findings have never been confirmed.

In this connexion we can mention an often quoted case of TAMPLIN, in which the use of alcohol was emphasized. The cords in the palm of the hand were said to disappear when the patient ceased to drink wine and beer, but reappeared when he drank to excess and disappeared again during a new period of abstinence.

J. Miscellaneous Theories

A number of theories which do not require any detailed analysis since they lack sufficient motivation will be mentioned here for the sake of completeness only.

BÄHR (1895) interpreted the disease as a general tendency to pathological changes in the connective tissue and attached great importance to the fact that his cases suffered from severe arteriosclerosis. In agreement with this theory, MAUCLAIRE (1913) was of the opinion that sclerosis in the aponeurosis is often coincident with sclerosis of the liver, arteries, spinal cord, penis or skin. CLAY (1944) referred to a case reported by BROOKS (1930) in which unilateral Dupuytren's contraction was associated with an aneurysm of the axillary artery, and almost entirely disappeared following surgical treatment of the aneurysm. In this connexion he recalled as examples of fibrosis associated with impairment of blood supply the contraction of Volkmann. DAVIS and FINESILVER (1932) called attention to a theory that Dupuytren's contraction was due to pressure of a cervical rib. X-ray photographs, however, showed no cervical rib to be present in their cases.

SACHS (1922) envisaged circulating fibroplastic substances in the blood, with a definite affinity to the fasciae and tunica albuginea. In analogy with this theory, a spontaneous healing of induratio penis plastica was believed to be a result of fibrolytic substances. KRINKE (1935) considered that the disease was caused by a disturbance in the collagenous metabolism.

JELIFFE (1931) believed that two factors produced the contraction. One was the persistence of more muscelo-tendinous tissue in the palmar aponeurosis of certain families (for the ideas of KROGIUS, p. 123). The other factor was the development of the grasping tendencies of individual personality development. In one case he had on psychoanalysis found a strong grasping tendency.

The suggestion that the contraction is due to a skin disease or a neoplasm has been advanced several times in the literature. These theories have already been referred to in the chapter on pathology.

2. The Writer's Observations

In connexion with the various theories on the aetiology of Dupuytren's contraction, the surgically treated cases in the writer's material will be discussed here briefly in relation to the most important of these theories.

Trauma. The material is divided into three groups, according to the degree of strain to which the hands were exposed in the various occupations represented. This classification can only be somewhat rough and in many cases the group to which the occupation is referred can be open to dispute. In the writer's series of 50 patients the occupation in 17 cases entailed practically no manual work, in 23 cases light or medium heavy manual work and in 10 cases heavy manual work.

The first group is chiefly comprised of people in various types of office-work, bank-clerks, accountants, business men, school teachers, valuers, lawyers, physicians. The second group comprised officers, engineers, physiotherapists, salesmen, publicans. The third group included patients occupied in cable-making and in wire-drawing, farmers, fishermen and factory workers.

Although the statements made by the patients cannot be afforded any particular significance, it is of interest to note that eight cases in the first group attributed the disease to repeated irritation to the hand from temporary heavy manual work or to golfing, fishing, rowing, injuries from rugby and fives, gripping the steering-wheel in motor-racing, gardening, etc. In one case the disease had remained dormant for nine years, but after starting heavy manual work on service duty, contraction was said to develop quickly. In five cases of the second group the disease was ascribed to gardening and sport, and two patients on active service attached importance to gripping the rifle and holding on to rough armoured surfaces. In the third group the constant pressure and wear on the palm in daily work was generally regarded as the cause of the disease.

Of the 50 cases in this material no less than 11 ascribed the condition to an accidental trauma. In four of them contraction developed following lacerated wounds of the palm or fingers and in one case following a poisoned hand. Four cases were attributed to distortion

or wrenching of the fingers. In one case the affected palm had been subject to acute excessive strain in physical training (gymnastics). In another case the disease started bilaterally after fracture of both wrists.

Neuropathy. None of the patients had suffered an earlier injury of the ulnar nerve, nor was there any evidence of ulnar neuritis on examination. In two instances the patients reported that any blow on the ulnar nerve caused radiating pains in corresponding fingers differing from the normal tingling sensation on the unaffected side. This symptom had appeared since the disease had developed and the writer regards it as a consequence of pressure on the digital nerves from the thickened aponeurosis. One of these cases was operated on by the writer. The digital nerves to these fingers were found to be displaced and buried in the centre of heavy fibrous masses. After the operation this nervous symptom disappeared.

One patient had suffered from syphilis in his youth, but this had responded to therapy. He was 65 years old at the time of examination and except for the finger contraction, which had started ten years previously, he was healthy. His brothers also suffered from Dupuytren's contraction, but had not had syphilis.

None of the patients examined by the writer had a clinical history suggesting any neurological origin of the disease.

Gout, Rheumatism and Senile Arthritis. In one case the operation for Dupuytren's contraction produced an acute attack of gout in the feet although the patient had not previously or later shown any manifestation of this complaint. In none of the patients was there a history of true rheumatic arthritis. Those who could recall slight or occasional "rheumatic" muscular pains never thought the side of contraction more affected. No exceptional incidence of gout or rheumatic diseases was to be found in their families. The majority of the patients treated belonged to relatively low age-groups. None of them had any symptoms indicative of arthritis deformans.

Endocrinopathy. On examination none of the patients showed symptoms of endocrine disturbances. There was no case of glycosuria, nor was any of them aware of any familial tendency to diabetes.

There were no clinical signs of latent tetany. In twelve cases a serum calcium determination was made. In nine of these cases the values were between 9 and 10.2 mg serum calcium/100 ml. In three cases the values were between 8.4 and 8.9 mg. Without further investigation, however, these latter values were no indication of a true decrease of serum calcium. It was unfortunately impossible to carry out a control since these examinations were made in the Out-Patients' Department and the patients lived at some distance from the hospital. It must also be emphasized that the Central Laboratory in London, to which these specimens were sent, considered values between 8.4 and 10 mg serum calcium/100 ml to be normal, since the calcium level of the blood appeared during recent years to show a decrease in general. This was thought to have some relation to the food shortage.

No endocrinopathic influence was proved in the present investigation.

The writer looked for any *abnormal tension or prominence of the tendon of the palmaris longus* muscle in 45 of the patients, but it could not be detected in any instance. Furthermore, the palmaris longus was lacking altogether in six cases.

None of the patients stated that the disease had started following an *infection*. One patient developed pulmonary *tuberculosis* simultaneously with the onset of Dupuytren's contraction. During his stay in the sanatorium the contraction was said to progress. The patient believed that this was due to keeping his hands flexed as an easy position in bed. It is of particular interest that the father of this patient and one of his father's sisters had Dupuytren's contraction but no confirmed tuberculosis. The patient had no siblings.

None of the patients examined had at any time worked with *lead* or had been in contact with this metal for long periods. No mention was made of lead colic, neuritis or other signs of chronic lead intoxication.

III. CONCLUSIONS

Conclusive evidence demonstrates that hereditary factors play a rôle in the aetiology of the disease, i. e. the predisposition to Dupuytren's contraction is confined to certain individuals. This does

not, nevertheless, exclude the possibility that certain environmental factors are of significance. Although this question has been extensively discussed in the literature for more than a century, no definite conclusions regarding the influence of any particular factors have been reached. The observations made by the present writer on a relatively large material appear to contradict the majority of the aetiological theories postulated.

The writer has expressed fresh views on the pathogenesis of the disease and was able to bring forward strong arguments in favour of that partial ruptures in the aponeurotic tissue are the origin of the pathological changes. The physico-chemical changes in the connective tissue which accompany increasing age increase the possibility of such ruptures. This gives a plausible explanation of the evident increase in frequency in the higher age-groups. The writer also demonstrated that the plantar aponeurosis is not infrequently involved by the same pathological process, and that its onset and development at this site definitely indicate a traumatic causal factor. Nevertheless, as the writer emphasized in the critical survey of the literature on this question, trauma alone cannot be the decisive factor, since the general frequency of the disease is too low in view of the fact that all individuals are exposed to traumatism to a greater or lesser extent. This does not exclude the possibility that *trauma is the causal factor in cases with a predisposition to the disease.*

This theory is supported by the fact that there is an increased frequency among persons in occupations with considerable mechanical strain on the hands (Table 10 A, p. 111). The explanation is probably that persons with little tendency to the disease only develop it on account of exceptional strain, thus giving an increased frequency in such occupational groups. The statistics in Table 10 A nevertheless give a somewhat confusing impression on account of some lack of conformity. This is partly dependent on the fact that the materials are relatively small and the standard errors considerable. In addition, mild cases have been included in varying frequencies. Nevertheless, the table consistently shows a high frequency among persons engaged in heavy manual labour as compared to those doing light or no manual work. The differences between the groups vary, but appear to be smallest in GERRITZEN's material which shows high frequencies. This indicates that if even mild cases are included, the difference

between those engaged in manual labour and those in other occupations is partly evened out. Thus manual labour appears to increase the severity of the disease but plays a smaller part in its aetiology than is indicated by the statistics of other workers.

Since occupational trauma has been shown to exert relatively little influence on the general frequency of the disease, it can hardly be expected that it will become evident in a small number of cases. The writer's material is no exception in this respect, but comprises occupations with varying degrees of manual strain. The patients' statements with regard to occupational trauma or various kinds of sport do not differ in any respect from those which could be expected from an arbitrarily selected control material.

It is of greater interest that in the writer's series 22 per cent stated that the finger contraction had its onset after a definite accidental trauma. There is no reason to doubt the truth of these statements, since there was no question of compensation, nor was the point stressed when questioning the patients. As a rule the disease had started several years previously and the contraction had not started until some time after the injury. It is therefore surprising that so many patients mentioned definite trauma as the cause and this must naturally have been of an unusual nature. If only slight blunt trauma had occurred, it is probable that this would have been forgotten. In any event, it would seldom have been combined with the appearance of subcutaneous nodules during the subsequent weeks or later on by progressive flexion deformity of the fingers. The writer considers that a traumatic lesion of the palmar aponeurosis as the origin of the disease is demonstrated in cases previously described, as well as in some of his own cases, in which a subcutaneous nodule remained at the site of injury. This slowly increased and after spreading in the extension of a finger started to cause contraction. Accidental lesions of the hand are extremely common, but are only exceptionally followed by Dupuytren's contraction, thus demonstrating the decisive importance of predisposition as well as its limited frequency. When it occurs, it permits direct observations of the onset and development of the disease.

An apparent contradiction to this process of reasoning is the case of tuberculosis described, in which the deformity was said to increase during the stay in bed. It is a clinical fact that if the fingers are kept flexed

more than is caused by the pathological process, the tissue involved rapidly retracts, whereas repeated extension practice can retard the flexion deformity. The case in question can probably be interpreted as a mere shrinkage of the connective tissue.

The majority of workers deny the influence of trauma as an aetiological factor. Their principal arguments will be discussed below, since they appear to be of particular interest in view of the writer's theory regarding pathogenesis:

1. *The larger proportion of people affected are those in whose life manual labour plays but a small part.*

This assumption is based on statistics from surgically treated material at a time when it was not possible for the surgeon to suppose that the hand involved would, after operation, be in a condition to perform heavy work. Under such conditions few workmen were able or could afford to take the risk of lengthy treatment which, although it might improve the appearance of the hand, could not infrequently lead to functional deterioration. Further, later investigations show that the frequency of the disease is increased in occupations placing considerable strain on the hands (Table 10 A).

The fact that the disease is common even among the "white-collar" class does not argue against trauma as a cause, but demonstrates the decisive importance of predisposition in the onset and development of the process. Partial rupture of the fibrillar structure of the aponeurosis, which the writer considers to be the starting point, has evidently greater chances of occurrence among manual workers, although all hands are at times subject to strain.

2. *The majority of people are right-handed and the right hand is thus exposed to more trauma and strain. Nevertheless, the left hand is involved in many unilateral cases.*

The last statements made in point one above can also be applied to this argument. The largest compilation of cases hitherto made (Table 4, p. 30) shows a statistically significant preponderance for the right hand in unilateral cases, which rather favours the theory of a traumatic factor in the disease.

3. *The thumb and adjacent fingers are most used, but the disease is least common in these fingers.*

The explanation of the peculiarity of the disease in this respect is with all probability to be found in the anatomy of the palmar aponeurosis, as described in the chapter on pathogenesis. There is usually no

extension from the aponeurosis to the thumb, and it is most powerfully developed towards the ulnar aspect. These anatomical facts can be considered to reflect the functional demands on the aponeurosis and in many functions, e. g. the act of grasping, the strain is greatest in the ulnar part of the hand.

4. *The bilateral and symmetrical character of the deformity.*

Even if the hand which is most used can reasonably be expected to be more exposed to trauma, both hands are in a similar position as regards predisposition and even, to a great extent, as regards external strain. Moreover, if one hand is deformed, more use is made of the other.

The symmetrical character of the disease does not imply that one hand is an exact copy of the other, but that as a result of the relatively uniform clinical appearance a certain likeness between the two sides appears.

To sum up, it can be stated that the arguments brought forward do not refute the course of the disease as described by the present writer, i. e. as a lesion of the aponeurosis in certain predisposed individuals, who in addition develop more or less excessive scar tissue when this lesion heals. Several reasons indicate that this is true of the majority of cases of Dupuytren's contraction.

It is probable that the tendency can also be acquired. Ledderhose's observations of similar conditions in the plantar aponeurosis following fractures of the lower extremities and only involving the injured side support this assumption, but it is not possible, in the light of present knowledge, to draw any definite conclusions in this respect. From the statements reported in the literature as well as from the writer's own material, it appears probable that such environmentally caused predisposition has little significance in the majority of cases. It is only the cases of epileptics, as demonstrated by the writer's investigations which confirm similar findings by Lund, that an abnormally high frequency of Dupuytren's contraction is found. The reason is as yet unknown, but several circumstances support the theory that prolonged treatment with phenobarbital especially predisposes these patients for Dupuytren's contraction.

The writer's theory regarding the pathogenesis of the disease (p. 59) leads to the natural conclusion that persons with predisposition to this deformity should not expose their hands to great strain. This is also in agreement with fairly widespread experience

and should be observed as a prophylactic measure, particularly in the choice of a trade or profession.

The probability of a number of the aetiological theories discussed here cannot be assessed on the grounds of clinical observations alone. In particular *Krogius' theory* that the disease is a developmental disturbance is widespread, but as far as the writer is aware, its premises have never been closely investigated. The embryology of the palmar aponeurosis was studied by the writer (p. 20) in order to determine its accuracy. This investigation showed that the aponeurosis develops from a continuation of the palmaris longus tendon and from vertically and horizontally directed independent primordia in the mesenchyme. No connexion or merging with the muscles was found, nor were any muscular elements in the aponeurosis observed. Even at the embryonal stage, the palmaris brevis muscle was clearly defined as a separate structure. This investigation thus gives no confirmation of Krogius' theory. The premises regarding the embryology of the palmar aponeurosis on which it was based were not found to agree with the actual conditions.

The writer's interpretation of the pathogenesis and aetiology of the disease makes it possible to regard Dupuytren's contraction as a result of general patho-physiological reactions in the connective tissue. The reason that these are chiefly localized to the palmar aponeurosis would depend on its specific anatomical structure and the often exceptional strain to which it is exposed. The writer's demonstration of the fact that the plantar aponeurosis is often similarly involved and also that patients suffering from Dupuytren's contraction showed knuckle-pads with identical tissue changes in a high frequency support this view. Present knowledge does not permit us to state definitely whether other pathological phenomena in the connective tissue such as keloids, induratio penis plastica and desmoids should be placed in the same category.

CHAPTER VIII

Treatment

I. GENERAL SURVEY

1. Non-operative Treatment

No form of non-operative treatment has hitherto given satisfactory results in the advanced stages of Dupuytren's contraction. It is therefore only infrequently that claims are found in the literature regarding cases successfully treated by some method. No large series with critical investigation of the results exist. Various forms of non-operative therapy are, however, still administered, particularly in early cases. It can therefore be of interest to give a short survey of the more usual forms.

A. Physiotherapy

The very nature of the disease as a slowly progressing contraction of the fingers makes it natural that gradual mechanical extension and different types of stretch therapy should be attempted.

Dupuytren found such methods ineffective, since they gave rise to excessive pain when the extension was continued for a long period. But the disastrous results in many cases of surgical intervention during the nineteenth century, owing to imperfect methods, often complicated by infections, favoured non-operative therapy and much ingenuity was given to the construction of various mechanical apparatus of which those of Eulenburg (1864), Adams (1878), Shoenborn (1871) and Windler (1886) are the best known. Spitzy (1916) recommended a stout steel spring fixed along the dorsum of the finger. Corrective gloves with pockets on the dorsal side for slips of spring steel were also used.

All those who have used prolonged forced extension have found Dupuytren's experiences confirmed. The fibrous cord causing the deformity cannot be lengthened to any notable degree owing to its

physico-chemical properties. Only by rupturing the cords can straightening be obtained, but this gives rise to pain and formation of new excessive scar tissue. This has during several months a tendency to retraction, and if the fingers are not continuously kept stretched during this time the deformity can increase and in addition there is always a tendency to recurrence.

If, however, in the earlier stages skilful extension exercise is applied and repeated regularly several times a day, it is possible that an increase of the flexion deformity could be prevented. The patient should also be recommended to wear a splint on the affected finger at night for the purpose of hyperextending it. VERRALL (1928) claimed to have successfully treated himself by constant stretching in this way. The writer has also seen a similar case, a physician with very severe familial and individual tendency to Dupuytren's contraction, the first symptoms appearing at the age of 20. Now (40 years later) there are heavy lumps and thick cords in the palm but the fingers can be extended satisfactorily, although in the morning it still takes some time to release them from the flexed position they have acquired during sleep. When, during past years, the extension exercises were abandoned for some time his fingers tended to contract.

In conclusion, this treatment could be used to prevent increase of the contraction but gradual mechanical extension is useless to cure it. Permanent extension for a long period should be avoided as it will cause stiffening of the finger joints. With the present improved operative procedures this kind of treatment has no place, except as a part of the post-operative treatment.

We find other physiotherapeutic measures proposed already enumerated by DUPUYTREN. He used fumigations, cataplasms, leeches, ointments, and also employed alkaline douches, simple and sulphur douches, without any success. As late as 1931, HABERLAND found hot soap-baths excellent and HAYWARD (1931) recommended hot-air therapy for mild cases. GRIESSMANN (1918) claimed to have achieved satisfactory results with pepsin-hydrochloric acid compresses, but his treatment was not adopted by other workers.

B. X-ray and Radium Theraphy

SOLOMON et al. (1925) reported on ten cases from a 10-year period, treated with *X-rays*. Four abandoned treatment, one was only slightly affected and the five remaining cases showed more or less considerable regression.

The results were said to be particularly satisfactory in early cases. In the discussion which followed this lecture, Desplats and Lamarque reported similar experiences, but Sluys preferred radium therapy. Beatty (1938) had since 1928 treated ten cases. In seven of them there was said to be an improvement. From the table of his cases it is found, however, that the change in long-standing cases seemed to have been very moderate, but it is difficult to judge the actual results from his description. Successful X-ray treatment of single cases was also claimed by Peugniez and Joly (1923), Alinat (1925), and others.

Radium was successfully used in a case in 1909 by Labeau and later by Specklin and Stoeber (1922), Apert (1925) with an improvement persisting after 4 and 7 years respectively. It was also advocated by Feuerstein (1936) and he regarded it as the treatment of choice in early cases although it did not give a perfect cosmetic result. Severe contractions in his nine cases were resistant, and for those he recommended surgical intervention followed by irradiation to prevent keloids. It should also be mentioned that in a case seen by A. Davis (1932) the application of a radium plaque caused an intractible and extremely painful burn but left the contraction unaffected.

The experience from this small number of patients supports the view one would be inclined to take on theoretical considerations, i. e. it is only the hypercellular tissue characteristic of the earlier stages of the disease that can be affected to some degree by irradiation.

This is in agreement with the as yet unpublished experience from Radiumhemmet, Stockholm; 149 patients suffering from Dupuytren's contraction were treated there with X-ray or radium therapy between 1921 and 1947. It was not possible to bring about any definite improvement by means of irradiation. The process, nevertheless, appeared to have become arrested, sometimes for several years. Very advanced cases with considerable fibrous changes did not appear to be affected by irradiation (Berven 1948).

Two cases in the writer's material also received X-ray therapy:

1) *Case A. C.*, aged 33. In 1943 both hands were re-operated for Dupuytren's contraction. Post-operatively deep X-ray treatment was given to the scars and to two recently developed subcutaneous lumps outside the field of operation, exactly resembling the nodules which had started the deformity. The treated area became reddened and there was some small degree of desquamation of the skin during the following weeks. The lumps gradually regressed and disappeared between nine months and twelve months after treatment. Three years afterwards they had not reappeared.

2) *Case J. H.*, aged 55. X-ray treatment was given soon after the first signs of Dupuytren's contraction had developed. Shortly afterwards a number of

lumps appeared in the palm and the patient felt that this treatment tended to further the development of the disease. Two years later he was operated on for progressing thickening and retraction of the palmar aponeurosis.

No further conclusions can be drawn from these two cases.

C. Local Injections

Thiosinamine (fibrolysin), the best known of so-called fibrolytic substances, was tried in the treatment of Dupuytren's contraction by Lengemann (1904) with favourable results in three early cases. About 40 injections were given in the course of a few months, together with intensive physiotherapy. He recommended it as a pre-operative procedure in severe cases. Jellinek (1906) obtained a complete cure in an early case treated with injections for over a year. Keen (1906), Schwalbach (1908) and other contemporary writers, also found this treatment valuable, whereas Friori (1910), Drehmann (1913), Horák (1914), Oehlecker (1930 b), Lexer (1931), Davis A. (1932), Wagner W. (1932), and others saw no effects from its use. With a few exceptions (for instance Sicard 1926), according to more recent investigators the results of this therapy cannot be regarded as encouraging. Tubby (1923) following excision of all contracted fascia rubbed fibrolysin into the wound in addition to injecting it into the surrounding tissues and beneath the healthy skin, and considered that this measure prevented the formation of scar tissue.

Fibrolysin therapy is painful, lengthy and without certain effect. In the only case of the writer's material previously treated with fibrolysin injections, the contraction of the fingers continued and made operation necessary.

Stahnke (1927) prepared a sterile solution of human fat ("humanol") from lipoma or omentum, and injected it into the palm at intervals of three weeks. It is difficult to interpret the good results he claimed in 12 cases, but it is possible that the systematic physiotherapy given contributed to a considerable degree. Partsch (1933) also obtained immediate excellent results with this treatment, but there was complete recurrence in all his cases after two years. Zur Verth (1930), and others, did not find "humanol" injections of any value.

Payr's pepsin solution was injected by Hesse (1931) with good results in three cases. Gold (1926), Oehlecker (1930), and others had nevertheless tried this method earlier without remarkable success.

Amongst other substances used systemically are solutions of copper sulphate (Horodynski 1917), paraffin, uric acid dissolved in potassium thiocyanate and choline (Hesse); Sachs (1922) suggested injection of pancreatic extract.

D. Electrical Theraphy

Eulenburg (1870) used fine gold needles introduced into the aponeurosis as anodes and passed a galvanic current through them. Others warned against this method, since severe burns could occur as well as adhesions of the tendon sheaths, etc. Hartmann (1908) passed a galvanic current through a bath of 4 per cent solution of sodium salicylate in which the affected hand grasped the negative electrode. The improvement noted must probably be ascribed to the simultaneous physical therapy, since as Tuffier demonstrated in 1908, the penetration in this ion therapy is only superficial. Charpentier and Bailleul (1926) used high-frequency currents, electrolysis and scarification alternately.

Nijkerk (1939) treated two cases of Dupuytren's contraction with "iontophores" in 1 per cent solution of potassium iodide. One of them was reported as cured clinically and the other, more severe, as improved. In the latter case treatment was given 117 times during a period of one year and nine months. Nijkerk pointed out that the electric current should not be too high, owing to the risk of hyperaemia, necrosis, and ulceration.

E. Miscellaneous Treatment

Finally, Vulpian's ointment (vaseline 20, potassium iodide 10, tincture of iodine 2) was used for some time in France (Amat 1886, and others). Iodine ointment was still used by Trumper(1931).

Durel (1888) believed that early cases could be resolved by general and local treatment of the rheumatic diathesis. In accordance with his theory that the contraction of the aponeurosis was a sign of focal infection, Byford (1921) recommended that all foci of infection should be removed.

Acting on the assumption that the disease is a manifestation of an endocrine disorder (as already discussed) different hormones as well as hypnotism were used as a therapeutic measure. Filderman (1931) injected autoblood combined with a hormone (testicular extract). Steinberg (1946), who believed in an abnormal tissue utilization of vitamin E, found this vitamin of value in the treatment of early and moderately advanced cases.

2. Operative Treatment

Rational surgical therapy in Dupuytren's contraction was only made possible by the realization that the disease is localized to the palmar aponeurosis. Previously, division of the flexor tendons had been performed with disastrous results, and the disease was considered with perfect truth to be incurable (Boyer 1931). Dupuytren's in-

contestable observations regarding the localization opened up a new era, even though in 1862 MALGAIGNE still maintained "c'est sur les tendons qu'il faut agir".

A survey is given below of the most important operative techniques used in this disease. It is evident that success only became possible after surgery became aseptic. It is nevertheless interesting to follow the development from an earlier date, when simple division of the retracted aponeurosis was performed, to later more radical measures and finally to complete aponeurosectomy, which is now recommended to a great extent. This survey is also justified by the fact that the older methods still have supporters.

A. Transverse Division of the Retracted Aponeurosis

a. *Subcutaneous Methods.* The first more adequate surgical therapy in Dupuytren's contraction was suggested by COOPER (1822). When the contracted band was narrow he advocated that it could with advantage be divided with a pointed bistoury introduced through a very small wound in the integument, and a splint applied to maintain the finger in a straight position. This method is often named after ADAMS (1878), who probably had the largest experience of it. He recommended multiple subcutaneous divisions, cutting off the cord from its connexions at its upper and lower extremities and also dividing the bands along the sides of the fingers. SMITH (1884, 1885) urged the importance of making as few incisions as possible to ensure maximum separation of the severed parts and thus to prevent reunion. Only in some cases did he find it advantageous to section the bands diagonally in order to obtain union of the cut ends in a lengthened position.

Several objections can be raised to subcutaneous methods. For instance, they do not allow division of the deep extensions of the palmar aponeurosis, which play a prominent part in this condition. Thus they often fail to relieve the deformity. They have also been said to lack value when the skin is largely adherent to the aponeurosis (ANNANDALE 1865). It is known that the masses of fibrous tissue can displace the digital vessels and nerves and these may also be completely enclosed in the pathological tissue. Even with the most accurate knowledge of the anatomy of the hand, it is not possible to foresee such topographical peculiarities, which make subcutaneous operations difficult and risky. Further, the result is entirely dependent on a very tedious and irksome after-treatment, since if the

fingers are not immediately extended and kept straight, re-contraction takes place. During the long time of splinting necessary, the patient is unable to work and permanent stiffening of the fingers is liable to occur. Finally, the diseased aponeurosis is not excised and recurrences are therefore more liable to take place than with other methods, as was found by Dickson (1928), and others.

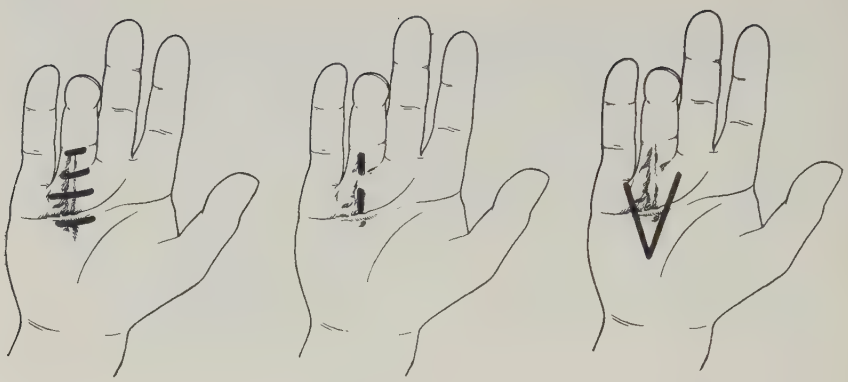
According to Macready (1890) Adams' estimate of recurrence with his method was 10 per cent. This figure seems surprisingly low and without details from his material it can hardly be accepted. In nine cases reported by Hedges (1896) there was said to be improvement. But from the records of these cases it is seen that in six of them the fingers gradually became more flexed. In the other three cases stiffness of the straightened fingers made them practically useless. A. Davis (1932) reported on six hands which had remained free from recurrence one to five years, while one showed partial and one complete return at intervals of two and four years respectively.

The few exact statements which exist regarding the late results of this surgical method indicate that it has not been satisfactory. Nevertheless, the method probably deserves some credit and the statements of a number of surgeons show the curative value of this incomplete procedure in certain cases (Fergusson 1846, Fisher 1885, Trélat 1888, Drehmann 1913, Roth 1920, 1928, Hohmann 1936, Meyerding 1936, and others).

Bunnell (1944) used subcutaneous fasciotomy in some severe cases to lengthen the skin gradually before complete excision of the aponeurosis was performed.

b. ***Open Methods.*** Dupuytren (1832) made multiple transverse incisions, dividing both the skin and the retracted palmar aponeurosis (Fig. 38). The fingers were then kept extended while the wounds were left to heal by granulation. Goyrand (1833) recommended longitudinal incisions of the skin to avoid gaping of the wound when straightening the finger. The cords were isolated and cut transversely and the skin edges sutured. This method was re-introduced under aseptic conditions by Hardie (1885) and was used by Richet (1873) and Abbé (1888), amongst others.

Instead of dividing the band transversely, Jobert and Blandin (1846) made a V-shaped incision pointing either proximally or distally. Cutting beneath the aponeurosis they elevated the triangular flap with the retracted aponeurosis left attached to the skin. Even though this flap



Dupuytren 1832. Goyrand 1833. Busch (acc. to Madelung 1875).

Fig. 38. Skin incisons used for simple division of the retracted palmar aponeurosis. Dupuytren originally used one or two incisions but according to Sanson (1833) he finally adopted four. For further details see text.

must be very rigid and unsuitable for covering any defect, the method was still favoured by Lannelongue, according to Durel (1888). He made direct closure by shifting the triangular flap V to Y.

Madelung (1875) published a similar procedure adopted by Busch (Fig. 38) but he dissected the flap consisting of skin only from the retracted aponeurosis, which was then divided where it was under tension. The skin flap was resutured without tension and the remaining defect either left for granulation or closed V—Y. Extension movements of the fingers and splinting were not started until the wound had entirely granulated.

This method was considered by many surgeons of the time to be the most suitable, since it allowed the best survey of the field of operation (Vogt 1881, Koenig 1889, Merker 1897, and others). But it was also mentioned that it involved much scarring of the palm, that the skin flap often necrotisized and adhesions of the tendon sheaths could develop (Zimmermann 1898, Lotheissen 1900, Hutchinson 1917, and others).

The disadvantages mentioned in connexion with the subcutaneous methods also apply here. In addition, the open healing of the wound gives rise to considerable masses of scar tissue which, on shrinkage, reproduce the deformity. Also, at the time this method was used, surgical intervention was not seldom accompanied by severe infection. The poor results obtained in conjunction with the risk of infection prevented these methods from becoming widespread.

B. Partial Excision of the Retracted Aponeurosis

Ritter (1930) made two incisions across the cord about one inch from each other and excised the intervening part.

From a longitudinal incision over the retracted cord and along its entire length, Gersuny (1884) undermined the skin edges and excised the thickened aponeurosis. This method was also recommended by Reeves (1885), Kocher (1887), Moser (1894) etc., and is generally associated with the name of Kocher (Fig. 39). Oehlecker (1930 a), instead of making a longitudinal incision, excised a narrow elliptic piece of skin over the cord. When the finger was extended after excision of the band the skin edges became well approximated and probably provided a better basis for healing than the skin covering the cord. To overcome the shortage of skin in severe cases, Bäärnhielm (1905) made two to three incisions across the tight skin edges (Fig. 39) and covered the defects with Thiersch grafts. In four cases the result of this procedure was reported as good.

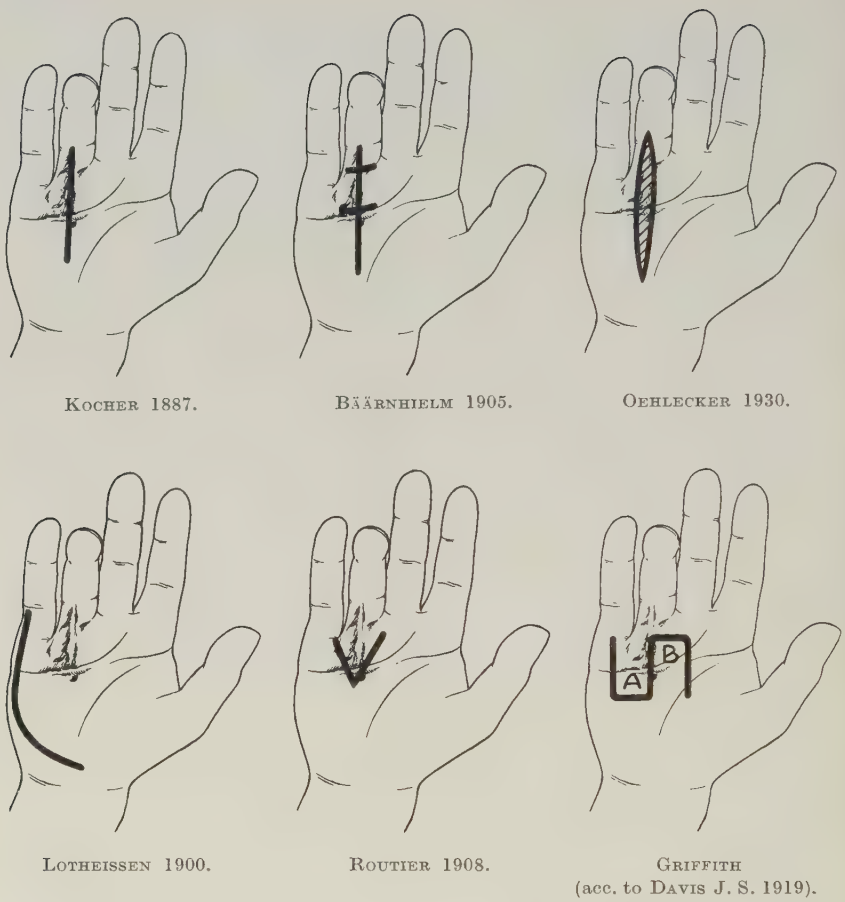
A general disadvantage of longitudinal incisions on the volar aspects of the hands is their tendency to retract after healing, giving rise to more or less pronounced finger contraction. This was already apparent from early experiences of the method, and since it is still used to no small extent, this disadvantage is still encountered. In order to avoid a large scar Russ (1908) performed excision through multiple small incisions along the cord, but this naturally gave very poor exposure of the field for operation.

Using the V-incision of Busch, Schmidt (1889) excised a localized thickening of the palmar aponeurosis. Using a similar approach, Routier (1908) and Palmer (1933) excised all fibrous tissue in the exposed area. They kept the skin flap in position without sutures by a pressure bandage. A modified procedure in Griffith's operation was described by S. Davis (1919), in which the thickened aponeurosis was excised through the incision shown in Fig. 39. The flaps A and B were then shifted by being turned transversely.

Lotheissen (1900) made a curved incision as shown in Fig. 39, reflected the skin and excised the thickened palmar aponeurosis. When the fingers are extended this flap slides down, leaving a raw area near the wrist, which may be grafted.

To sum up, it can be pointed out that experience shows that operations consisting of partial excision of the palmar aponeurosis are often followed by a relapse, since the process extends in the remaining portions of the aponeurosis (Daeschler 1903, and others).

The disappointing results of excision of the diseased part only of the aponeurosis are demonstrated from the figures given by A. Davis



Kocher 1887. Bäärnhielm 1905. Oehlecker 1930.

Lotheissen 1900. Routier 1908. Griffith (acc. to Davis J. S. 1919).

Fig. 39. Incisions used for partial excision of the palmar aponeurosis. For details see text.

(1932). In a follow-up investigation of 31 cases he found that after an average of three years not more than 38 per cent were completely cured, 32 per cent showed partial and 10 per cent complete return of the contraction, while 20 per cent were definitely worse.

C. Complete Excision of the Palmar Aponeurosis (Aponeurosectomy)

Keen (1906) and Iversen (1909) reported cases in which the palmar aponeurosis was involved to such an extent that they excised it entirely. About 1900, Lexer (who published his results in 1931) began as a matter

of routine, irrespective of the extent of the pathological process, to excise the entire aponeurosis, including its digital extensions, deep connexions and the fascia of the thenar region, as well as the part of the palmar skin involved. Aponeurosectomy has since then become increasingly accepted as the best method in the treatment of Dupuytren's contraction. The palmar incisions suggested for this procedure are outlined in Figs. 40 and 41.

Gill (1919) demonstrated the advantage of making incisions along the line of the natural crease of the skin, since this gives rise to less scarring than incisions transverse to the creases, and many of the methods suggested consider this principle. The majority of surgeons agree that the intervention should take place in a bloodless field in order to overcome the difficulties in dissection. Stern (1941), however, did not use a tourniquet, since after dissection of the skin he located the course of the digital blood vessels under the aponeurosis by palpation.

Since this therapeutic principle has been adopted more satisfactory and permanent results have been achieved. Lexer stated that in approximately 200 patients operated during 30 years he had seen very few relapses, and mentioned two cases without relapses after 25 and 28 years respectively. The results of other surgeons are seen in Table 12, p. 168.

General anaesthesia as well as various forms of block anaesthesia have been used, but no decisive advantages of any particular method have been stated.

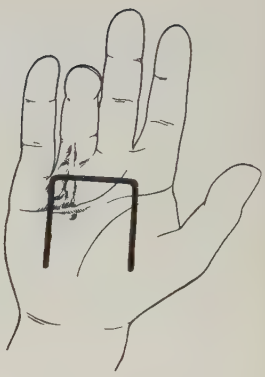
D. Various Methods for the Replacement of Palmar Skin in Dupuytren's Contraction

Orbach (1934), who was much in favour of multiple open divisions of the diseased palmar aponeurosis, covered the gaps following extension of the fingers with *Thiersch grafts*. Of his 16 cases, 9 were re-examined one to three years later and 7 were reported as cured. As mentioned, Bäärnhielm (1905) utilized thin grafts in a similar manner, and von Seemen (1936) swung a big rotation flap into the palm from the ulnar and dorsal surface of the hand and covered the secondary defect with a Thiersch graft.

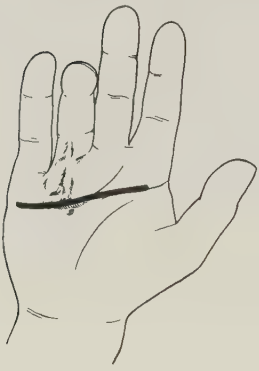
Our present knowledge of the considerable shrinking tendency of thin skin grafts makes it difficult to agree with those writers who advocate such grafts to replace the palmar skin. These must also be considered unsuitable in view of the great strain to which this region of the hand is exposed.

Iversen 1909.

Lexer 1931.

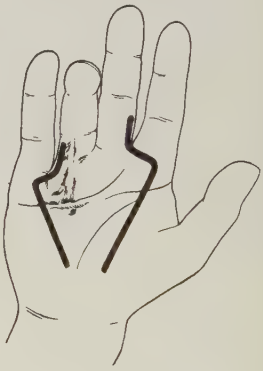


Keen 1906.



Gill 1919,
Kanavel 1929 I.

Kanavel 1929 II.



Desplas,
Meillère 1932.

Moure 1932.

Davis,
Finesilver 1932 I.

Davis,
Finesilver 1932 II.

Fig. 40

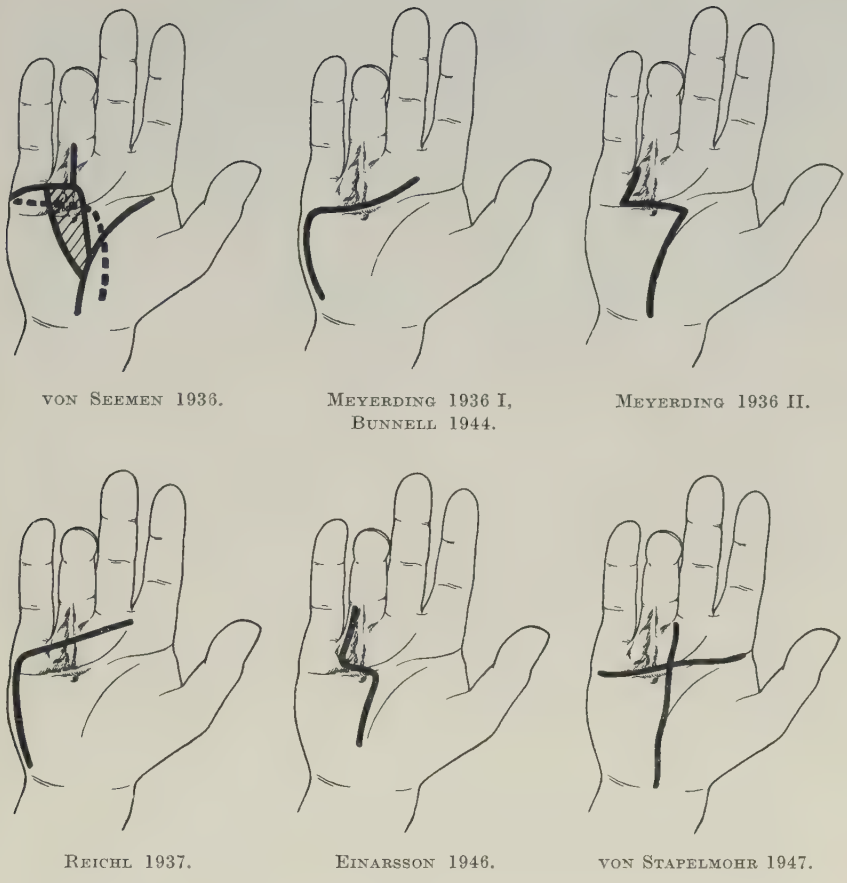


Fig. 41

Figs. 40 and 41. Incisions used for complete excision of the palmar aponeurosis.

Lexer — shaded area was excised and replaced with a full thickness skin graft; von Seemen — dotted line indicating the extension of the incision to the dorsal aspect of the hand. For further details and for von Stapelmohr's technique see page 148. (Several drawings are made from descriptions only in the original papers and thus may not in detail represent the intentions of these authors.)

Full-thickness skin grafting to relieve Dupuytren's contraction was employed by S. Davis (1919), Blair (1924), Lexer (1931), Frankenthal (1937), Gillies (1945), Grenabo (1946), Langvad-Nielsen (1946), etc. Skinner (1941) used tunnel grafting in selected cases. From an incision along the ulnar surface of the hand he freed the skin and removed all contracted fascia. Two or three full-thickness grafts were placed transversely under the area of devitalized skin. At the first dressing,

on the tenth or fourteenth day, the skin was cut over the grafts. Applying the same principle, PALMER and SOUTHWORTH (1945) advocated a "bridge operation" in cases with a single band of contracted fascia. From two parallel longitudinal incisions on either side of the band, the contraction together with its overlying skin, was lifted like a bridge. A full-thickness graft or a thick split graft was applied beneath, and by extending the finger, the bridge exerted firm pressure on the graft. When it had taken, the diseased bridge was excised.

A special technique was employed by VON STAPELMOHR (1947). Using various types of cross incisions (most frequently that seen in Fig. 41) he trimmed the palmar skin to the thickness of Wolfe grafts. The flaps were fixed with deep mattress sutures tied over buttons in the palm, the wound edges carefully approximated and the hand splinted in extension for seven to ten days. 22 such grafts gave favourable results in all cases.

BERGER (1892) appears to be the first to apply a modified *Italian plasty* in the treatment of Dupuytren's contraction. In cases of long standing he made a wide excision of the palmar skin and aponeurosis and replaced it with a pedicled flap from the chest. This method was recommended in severe cases by GUINEBAULT (1897), FREDET (1932) and was also resorted to by W. WAGNER (1932) when the palmar skin died following partial excision of the aponeurosis. S. DAVIS (1919), LEXER (1931), besides free grafts, also used abdominal flaps and OEHLECKER (1930 a) recommended a pedicled flap from the scrotum for replacement of the palmar skin.

E. Subcutaneous Fat and Fascial Implantation

To prevent subsequent adhesion of the palmar skin to the flexor tendons, PEISER (1917), GILL (1919), RAMSTEDT (1933), inserted a free fat transplant from the thigh beneath the skin. For the same purpose SPITZY (1916) recommended insertion of vegetal fat or swine fat. REICHL (1937) poured sterile paraffin into the wound. DESPLAS and MEILLÈRE (1932) tried amniotic membrane, but found it unnecessary and possibly deleterious.

WOOLF (1920) transplanted a piece of fascia lata and fat. ABBOTT (1929) in one case successfully replaced the diseased aponeurosis by a piece of fascia lata.

These methods were given a critical consideration by DAVIS (1932), who for various reasons doubted their usefulness. No experiences have later been reported which justify their use. It should also be remembered that an extremely long convalescence is required in these procedures, for instance, practically six months in ABBOTT's case.

Fig. 42. Operation according to PALMÉN (1932) for release of finger contraction (**A** — lines of incision; **B** — completed).

F. Operations on the Fingers

With the modern surgical methods described above, the treatment of the palm itself has reached a solution which is in principle satisfactory to a great extent. Little attention has, on the other hand, been paid to surgical intervention where the disease is localized to the fingers. Various skin incisions have been proposed for excision of the retracted bands to the fingers; most of them being longitudinal and apt to cause cicatricial contractions if they are not placed laterally. To avoid this, GILL (1919) recommended a transverse incision at the base of the finger involved.

As the finger contraction progresses, the skin on the palmar aspect of the fingers shrinks. This makes it impossible, when operating, to stretch the fingers even when the retracted aponeurosis has been excised. Hitherto only one plastic operation has been suggested to overcome this shortage of skin. PALMÉN (1932) used a series of transverse Y—V incisions (Fig. 42) and reported satisfactory results in seven cases. This method does not, however, appear ideal. As mentioned, BUNNELL in certain cases performed preoperative subcutaneous fasciotomy in order to lengthen the skin. An account is given on page 155 of the excellent solution of this important problem afforded by MCINDOE's operation.

According to NÉLATON (1908), OMBRÉDANNE, after removal of the aponeurotic band, resected the interphalangeal joint to straighten the finger. This procedure was also recommended by KOSIŃSKI (1938) and in addition he divided the flexor tendons. HUTCHINSON (1917) considered

that the only way to overcome permanent flexion deformity of the proximal interphalangeal finger joint was by excision of the head of the proximal phalanx. He did this from a dorsal semilunar incision over the joint and at the same time he slightly shortened the extensor tendon. Eckstein (1922) thought it possible to adjust the length of the bony phalanx to the shortened soft tissues by excising one or two centimetres from the middle part of the proximal phalanx. Orthopaedic operations must naturally be regarded as an emergency measure if there is severe involvement of the fingers. The majority of surgeons appear to prefer amputation in such cases.

II. THE WRITER's MATERIAL

The patients reported on in this paper all underwent surgical intervention according to a new operative procedure introduced by McIndoe. The method will be given in detail, by kind permission of Sir Archibald McIndoe, since it is described here for the first time *in extenso*.

1. McIndoe's Operation

Principles of Operation

It is now generally recognized that the entire palmar aponeurosis must be excised if a permanent cure for Dupuytren's contraction is to be achieved. McIndoe's operation consists of radical excision of the palmar aponeurosis and its extensions, including both the normal and the pathological areas. In this way both the primary cause of the deformity and the premises for relapse are eliminated. The incision in the palm is made transversely in the natural creases in order to avoid disabling scarring. When necessary, plastic operations on the volar aspect of the contracted fingers are performed to overcome the shortage of skin at these sites.

Measures to counteract secondary changes are taken in the after-treatment.

Indications for Operation

The primary aim of the operation is to restore the normal function of the hand and also to forestall an extension of the process. Indications for operation can therefore be considered to exist at all stages of

the disease, although it should preferably be performed before secondary changes in the joints have developed. There is, however, no reason to refuse a patient's request (made when functional disturbance has not yet occurred) for an operation at a later date, when a permanent flexion deformity has started to develop. Moreover, patients are then more favourably disposed to a radical operation and the resulting relatively long convalescence. If only a localized nodule is present in the aponeurosis it is always advisable to ensure, before operating, that there is a progressive tendency. The suggestion that surgical treatment should be deferred until the contraction has remained unchanged for several months is obviously unacceptable, since in progressive cases the consequences would be severe.

The writer is in complete agreement with VON STAPELMOHR's earlier suggestion that in cases of bilateral deformity the hand least affected should be operated on first. In severe cases this is very reasonable. Poor results in a badly deformed hand, followed by lengthy after-treatment, would make the patient disinclined to submit to an operation on the less affected hand where the results could be expected to be satisfactory.

The only contra-indications for the operation are those of a general medical and surgical nature.

Anaesthesia

General as well as brachial plexus anaesthesia (for technique: MACINTOSH and MUSHIN 1944) has been used without disadvantage. The patients suffering from this disease are frequently elderly, and brachial plexus anaesthesia is often to be preferred as a lenient form of anaesthesia. Blocking of the ulnar and median nerve at the wrist or local anaesthesia are unsuitable, since the patients will then suffer from ischaemic pains in the arm as a tourniquet is used.

Preparation for Operation

The evening preceding the operation, the hand to be operated on is thoroughly cleaned by scrubbing, using a soft brush, soap and water. The hand is wrapped in a piece of gauze soaked in alcohol and covered with a sterile dressing. This is left until the patient is on the operating table, when the skin of the hand wrist is prepared for operation in the

usual way using an antiseptic solution. The importance of careful sterilization of the skin, as well as operation with strict aseptic technique is obvious. Infection of the palm would be disastrous.

Operative Technique (Figs. 43—46)

The minute dissections required in this operation cannot be accurately performed without a bloodless field. Exsanguination of the arm is achieved by winding an Esmarch bandage from the hand up the arm above the elbow. The pressure of a tourniquet round the upper arm is then raised to about 300 mm mercury and kept there during the entire operation.

A wide transverse incision is made along the distal palmar crease. The palmar skin is dissected upward and downward, exposing the aponeurosis from the height of the distal border of the transverse carpal ligament to the finger webs and along its prolongations in front of the base of the finger. Undermining the skin it may be necessary to cut through the dermal layer in severely affected areas, especially over prominent cords. Otherwise, the subcutaneous layer of fat is left on the flaps. It is rarely necessary to excise any part of it. To provide the best basis for healing of the skin edges it may, however, be of advantage in some cases to make a narrow elliptical excision of the deepened ulnar part of the crease incised. Gentle handling of the skin is important to obtain primary healing. Skin edges should not be grasped with heavy forceps but preferably held with fine tissue hooks as used in plastic surgery.

As a preliminary step in severe cases, prominent retracted cords are divided transversely to allow for extension of the contracted fingers before dissection of the palmar aponeurosis, thus giving a wider exposure of the field for operation. It was described in the chapter on anatomy how the distal third of the middle palmar compartment is subdivided by paratendinous septa connecting the palmar aponeurosis with the deep fascia of the palm. To remove the aponeurosis with these deep extensions, longitudinal incisions are made over the alternate canals for flexor tendons, nerves and vessels. This may be facilitated by inserting a grooved director under the aponeurosis, as suggested earlier by Stern. Longitudinal incisions in the line of underlying anatomical structures must be regarded as a safer procedure than

Fig. 43. This and the following colour photographs illustrate the procedure in McIndoe's operation. (Case A. E. p. 163.) Op. T. S.
Transverse incision in distal palmar crease and Z-shaped incision over base of contracted little finger outlined with Bonney's blue.

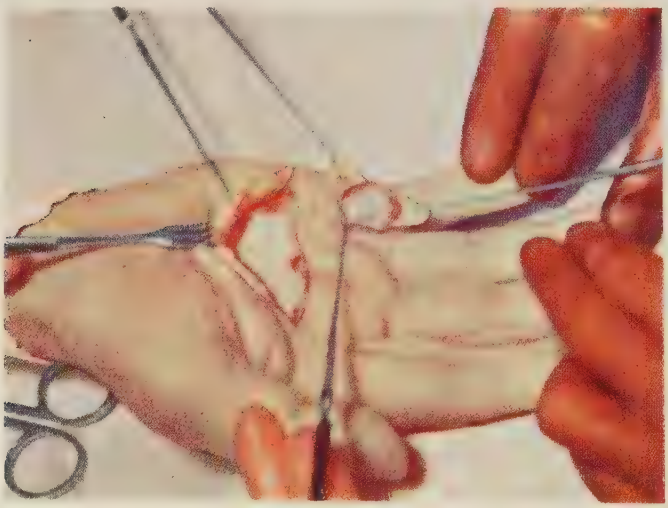


Fig. 44. Hand exsanguinated and skin incisions made, exposing the palmar aponeurosis. Note the wide approach obtained by raising the Z-plastic flaps. Skin bridge between finger and palmar incisions undermined as well as the entire palmar skin.

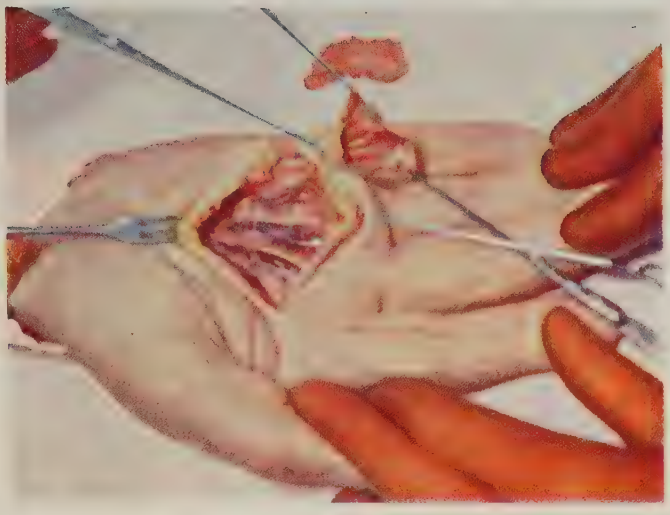


Fig. 45. Palmar aponeurosis completely excised, presenting the anatomical structures of the palm as in a dissected specimen. Note tendon sheaths preserved (4th finger). Fibrous lump (about 3×1.5×1 cm) dissected out of little finger, placed beside it, leaving the digital nerves and vessels freed. Free extension of little finger.

Fig. 46. Operation finished. Skin margins accurately approximated, palmar wound drained. Z-plastic completed with flaps transposed and sutured without tension, allowing for free extension of little finger. The main suture line lies transversely. Note excellent colour of palmar skin and flaps.

transverse incisions. The longitudinal sections of the aponeurosis thus formed are excised, cutting the paratendinous septa close to the deep palmar fascia. The flexor tendons on one side of each paratendinous septum and nerves, vessels and lumbrical muscle on the other are held aside by blunt retractors.

In parts where the anatomy appears normal the palmar aponeurosis with its deep attachments can, with careful and methodical dissection, be removed without danger of injury to adjacent fine structures. But the operation is by no means easy where the aponeurosis consists of dense fibrous masses which intimately enclose the anatomical structures passing through it. Much patience and meticulous care must be exercised when freeing these structures. The digital nerves in particular may present great difficulties, since they are often displaced by the new formation of fibrous tissue. The dissection is, however, facilitated if the nerves can first be located outside the pathological tissue and then followed through it. It should be stressed that it is possible to free nerves, vessels and muscles, as well as tendon sheaths completely, as there is a cleavage plane around them and the masses never invade these structures. Consequently there is no need to open the tendon sheaths for radical excision. Many cases give an opportunity to confirm the findings made long ago, viz. that the deep extensions of the palmar aponeurosis contribute considerably to the flexion deformity, especially the parts attached to the sides of the proximal phalanges. Their excision is therefore essential.

Prolongations of the diseased aponeurosis to the second phalanx cannot be dealt with from a palmar incision, and operative methods for this problem hitherto in vogue cannot be regarded as entirely satisfactory. By applying the ingenious Z-plastic flap operation for relaxation of the contracted fingers in Dupuytren's contraction, McIndoe has made an important contribution to the operative treatment in this disease. The technique and method are shown in Figs. 43—46. The principle of this procedure is to transfer skin available in one direction to an axis transverse to it. This is done by transposing two triangular flaps, the incision line being a Z or a Z in reverse. The flaps must be estimated with skill and care to fit exactly when transposed and so that the skin in the line of the finger is lengthened. A certain amount of experience is demanded to judge the extent to which

these flaps can withstand impairment of blood supply. Delicate handling of the flaps is essential.

Figs. 44 and 45 give an impression of the wide approach obtained to the volar aspect of the finger by this incision, unsurpassed by any other method. Working from this finger incision and the palmar incision as well, the pathological tissue down the finger can be completely removed and the good exposure facilitates freeing of digital nerves and vessels. If required, a double Z-incision may be made on the same finger. After complete excision of the retracted aponeurosis and its extensions, the contracted fingers can be extended more than the shortened skin will allow for and the value of the Z-plastic operation is demonstrated.

Secondary changes of the finger joints may prevent full extension of the contracted fingers. No attempt is made to overcome this by forcible extension as this would rupture joint capsules as well as other soft tissues with subsequent formation of scar tissue. Secondary changes are therefore left for prolonged after-treatment.

Removal of the tourniquet is followed by immediate profuse bleeding. A few minutes' pressure against swabs may, however, arrest it completely as no larger vessels should have been injured during the operation. Branches from the deep volar arch which anastomose with the common volar digital arteries are unavoidably sectioned by removing the paratendinous septa. It is, however, only in the metacarpophalangeal region that bleeding from these connexions will possibly fail to stop spontaneously. To secure haemostases of these deep cut ends by ligature if required, good exposure is necessary. The wound must be perfectly dry before it is closed.

Great care should be given to accurate adjustment in skin closure to minimize the time for healing so that intensive physiotherapy can be given as soon as possible. Nylon or fine stainless steel wire is preferably used for skin sutures, taking small "bites" not too tightly tied and using atraumatic technique. The suture lines are covered with Tulle gras (vaseline mesh).

To prevent accumulation of a haematoma, a small rubber tube drain is inserted to the ulnar side of the palmar incision. For the same purpose, and to prevent oozing from the large tissue surfaces, the hand is bandaged with moderate pressure to the palm, using wool

soaked in sterile paraffin, dry wool and a crepe bandage. No splint is used, but the bandage gives sufficient support to fix the metacarpophalangeal joints in an almost straight position and the interphalangeal joints in an easy semiflexed one. The distal thirds of the fingers and the thumb are left free. It is of importance that there is not too much pressure on the palm since this would disturb the circulation of the flaps and eventually cause necrosis.

Post-operative Care

Post-operatively, the hand is placed elevated on a pillow and watched carefully for the first 24 hours. If cyanosis or swelling of the fingers occurs the bandage should be loosened. The first dressing is made on the day after operation, when the drain is removed. If there are no signs of complications the bandage is re-applied with somewhat less pressure, leaving the interphalangeal joints free for active movements, which are done several times a day for the following week to prevent stiffness and adhesions. If there is no rise of temperature or local pain during that time, there is no need for another dressing. After a week a few stitches can be removed and more intensive movements started. As healing is slow in the palm, the last stitches must not be removed until the 14th or 16th day.

2. After-treatment

As mentioned previously, in advanced cases of long standing, the fingers cannot be extended fully after complete excision of the aponeurosis, owing to the changes in the joints. In order to remedy this, rational after-treatment is of great importance. It is not possible here to give details of its application in individual cases but only some important principles for its general use.

It is evident that joint changes of the kind described on p. 52, which are a result of a permanent flexion position of the joint over a long period, cannot be corrected and function retained by forcible extension. The volar part of the joint capsule can certainly be extended and the fingers stretched with prolonged splinting. Nevertheless, continuous splinting is accompanied by stiffness of the finger joints, since when they are immobilized in extension, the collateral ligaments retract and make flexion impossible. "Stiffness of the fingers resulting from

treatment may prove a worse evil than their original contraction" (Hutchinson 1917). He rightly regarded prolonged and irksome splinting as responsible for many stiff fingers following operation. Meyerding (1940) on the contrary, pointed out on the basis of experience that "when contraction recurs, it usually is in those cases in which operation has been performed with apparent success, but fixation has either not been applied or has been continued for an insufficient time".

These statements show the unfortunate consequences of the rigid application of various principles. It is generally agreed that some kind of post-operative extension treatment is necessary. The method used in the writer's material consisted, in principle, of a gradual straightening of the fingers, but with the preservation of their flexion capacity. It was carried out as follows:

No splint was applied in connexion with the operation and the interphalangeal joints were left free for movement which was started on the day after the operation. The movements are not extreme and are aimed at retaining the extension gained by operation and preventing the occurrence of stiffness in the fingers but not at correcting any residual shortage of extension. The flexions are carried out to the extent permitted by the bandage, but extension must not be allowed to cause distension of the suture line and thus retard healing. The movements also reduce any possible oedema of the fingers which can otherwise contribute to stiffness of the joints.

As soon as the incisions are healed (after about two weeks) more intensive physiotherapy is started, in which active movements and splinting in extension are equally important. Extension should never be sufficient to cause pain. The movements are carried out twice or three times daily in a warm hand bath, when flexion exercises are particularly stressed. In between, it is sufficient in mild cases for the patient to carry out frequent passive stretching. In severe cases, splinting in extension is required. This is only applied during short intervals in the daytime but remains in position at night. Various apparatus has been used, amongst others individually fitted splints of plastic with permanent extension by means of rubber bands to the fingers. In the writer's opinion, however, such complicated apparatus has no advantages over a simple plane volar splint, in which extension is brought about by fixing it with an elastic bandage round the hand.

Treatment should be continued as long as there is any tendency to contraction of the fingers. For a long time after the operation it is also advantageous if the patients make a habit of extending their fingers several times a day and flexing them to the maximum extent. Massage and various forms of radiant heat are not so important but can contribute to the favourable results.

Methodical after-treatment along these lines proved suitable in the writer's cases. In the cases shown in Figs. 48 and 50, the flexion deformity was decreased by two-thirds by the operation, and the remaining defect was overcome by after-treatment.

Although this treatment is simple in principle, it can be relatively difficult in practice. The reaction varies in individual cases and patients suffering from Dupuytren's contraction have a tendency to stiffness of the finger joints. It is therefore important to have a continuous, competent check on the after-treatment, which in many cases should be given by a qualified physiotherapist.

3. Operative Results

In order to judge the results of the treatment accurately, it is necessary to classify the cases according to the degree of the deformity present before the operation. Every finger should in fact be classified separately, but this is impracticable and the focus of interest is, in any case, the function of the hand as a whole. Meyerding (1936, 1940), amongst others, described principles for simple, schematic classification. His system, with the minor modifications given by Einarsson (1946), were applied to the writer's material (Table 11) as follows:

Grade I. — Thickening of the palmar aponeurosis with major or minor flexion deformity of one finger only.

Grade II. — Flexion deformity of more than one finger, nowhere attaining 60 degrees.

Grade III. — Flexion deformity of more than one finger, exceeding 60 degrees in at least one joint.

Grade IV. — Major or minor flexion deformity of all fingers.

This grading is naturally open to criticism. For example, it is questionable whether a major flexion deformity with secondary joint

changes in two or three fingers is less disabling than moderate involvement of all the fingers. Nevertheless, the surgical intervention is considerably more difficult and the outcome less hopeful in the former case. The classification mentioned will be used here since it is important that uniform methods should be more widely used, amongst other reasons for the comparison of operative results in different series.

Aponeurosectomy, in principle according to the method previously described as McIndoe's operation, was performed on the fifty patients (68 hands) mentioned in Chapter II. Forty cases were operated on by Sir Archibald McIndoe, and ten by the writer. The time elapsing between the operation and that at which the results were assessed varied, as follows:

6 months—1 year	12 hands
> 1 year	29 »
> 2 years	9 »
> 3 »	13 »
> 4 »	3 »
> 5 »	2 »

In 37 cases the after-examination was made in the summer of 1946. The patients were instructed to report any subsequent change in their condition. No deterioration has later been reported to the hospital at which they were treated. In the other 13 cases statements concerning their conditions were obtained at a later date.

No less than 16 of these 50 patients had previously undergone surgical treatment at other hospitals. Recurrences had occurred owing to insufficient intervention (section or partial excision of the palmar aponeurosis). The recurrence had usually occurred relatively soon after the operation and was then generally in the field of operation. Later recurrences were in remaining parts of the aponeurosis.

Since the operative results obviously depend on the degree of deformity present at the time of operation, the results are given in each of the four groups in which the patient was graded (Table 11). A short commentary on each of these groups will be given.

Grade I (16 cases). — *The results were excellent in all 16 cases.* The wound healed in about three weeks and the patient was then able to

Table 11

Results of Complete Excision of the Palmar Aponeurosis in the Writer's Material

Grade	Number of hands	Excellent		Fair	Poor
		Appearance and function perfect	Function perfect*		
I	16	16	—	—	—
II	15	15	—	—	—
III	29	11	12	6	—
IV	9	—	3	6	—
	69	42	15	12	—
		61 %	22 %	17 %	

* Remaining flexion deformity of proximal interphalangeal joint of little finger only. See text.

start light work while after-treatment was continued. In one case healing was retarded about two weeks by post-operative haematoma and in another case as a result of mild infection. Both of these patients were able to work after about 10 weeks.

The cases shown in Figs. 47 and 48 belong to this grade.

Grade II (15 cases). — *The results were excellent in 14 cases.* In one of these there was an insignificant shortage of extension in the proximal interphalangeal joint of the little finger caused by a longitudinal scar from a previous operation. In three cases healing was retarded by limited necrosis of the skin at the line of suture. One patient developed spasm of the abductor muscle of the little finger, necessitating tenotomy of the affected muscle. This patient was capable of working after 11 weeks and the other patients within 8 weeks.

In one case partial excision of the palmar aponeurosis was performed. There was a recurrence in a few months' time and re-operation with excision of the entire aponeurosis was performed six months later with excellent result, maintained after four years.

A more detailed report of the case classified as fair is given here:

Case S. J., aged 52. *Left hand:* Dupuytren's contraction of 6 years' standing, involving 4th and 5th fingers. Operated 4.7. 45. Haematoma developed post-operatively, delaying healing and causing thickening of the palm. A few

months after the operation the patient was admitted to a mental hospital, where he died in 1946. One year after the operation improvement was reported, but thickening of the palm still prevented complete extension of the fingers.

The haematoma, as well as the mental condition which interfered with after-treatment, could explain why a perfect result was not obtained in this case.

Fig. 49 shows a case belonging to this grade.

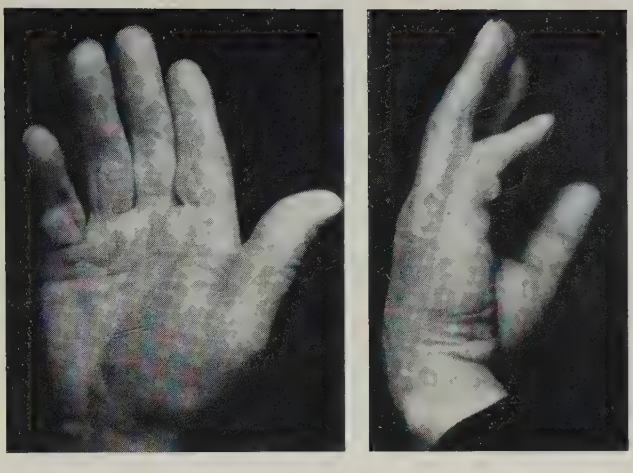
Grade III (29 cases). — *The results were excellent in 23 cases.* Included in this number are 8 cases in which a more or less pronounced shortage of extension remained only in the proximal interphalangeal joint of the little finger, 3 cases in which the two distal phalanges of the little finger were amputated, and 1 case in which the two distal phalanges of the ring finger were amputated. In Table 11 these 12 cases are classified as functionally but not anatomically perfect. Secondary changes of the joints were the chief reasons for the residual flexion as well as for amputation. It is possible that these could have been ameliorated in some of the cases by intensive physiotherapy. Moderate flexion position in the interphalangeal joints of the little finger but with no impairment of flexion is usually so insignificant functionally that the patient is not inconvenienced and does not consider it worth while undergoing lengthy after-treatment.

The results were fair in 6 cases. From a surgical standpoint the results were excellent in these cases too. There was no recurrence, the palms were normal in appearance as were the position and function of the metacarpophalangeal joints. Normal function in the interphalangeal joints was not, however, achieved. This was chiefly because they were all advanced cases with severe secondary changes in the joints. In one case it is possible that insufficient after-treatment was a contributory cause. In two cases post-operative complications had unfavourable effects, as described briefly in the following:

1) *Case J. M.*, aged 36. *Left hand:* Dupuytren's contraction of 11 years' standing; 4th and 5th fingers were fully flexed with about 10 degrees of movement in the interphalangeal joints. Excision of the aponeurosis 30.10. 43 gave improvement. Post-operatively the skin over the volar aspect of the fingers involved partly sloughed, due to infection. The exposed areas were grafted and healing was complete after 6 weeks.

10.9. 46. Three years after the operation there was no recurrence, the palm was soft and all metacarpophalangeal joints normal. The interphalangeal joints of the 4th and 5th fingers were ankylosed in a semi-flexed position. It is probable that infection in connexion with the fixation necessary for successful grafting had contributed to the ankylosis. Since the hand is opened for gripping, function is fairly good and the patient considers it a useful hand.

A



B

Fig. 47. Case A. E., aged 69. Business manager. Dupuytren's contraction in right hand of three years' duration. Cause unknown. No family history of similar complaint.

2.5.1947. *Operation* (T. S.): Aponeurosectomy according to McIndoe (v. Figs. 43—46, p. 153).

A — Condition before operation. Note retracted cord in the palm towards the little finger with heavy lump over base of this finger. Grade I.

B - 5 months after operation. (The wound healed in about 3 weeks; function perfect since then.)

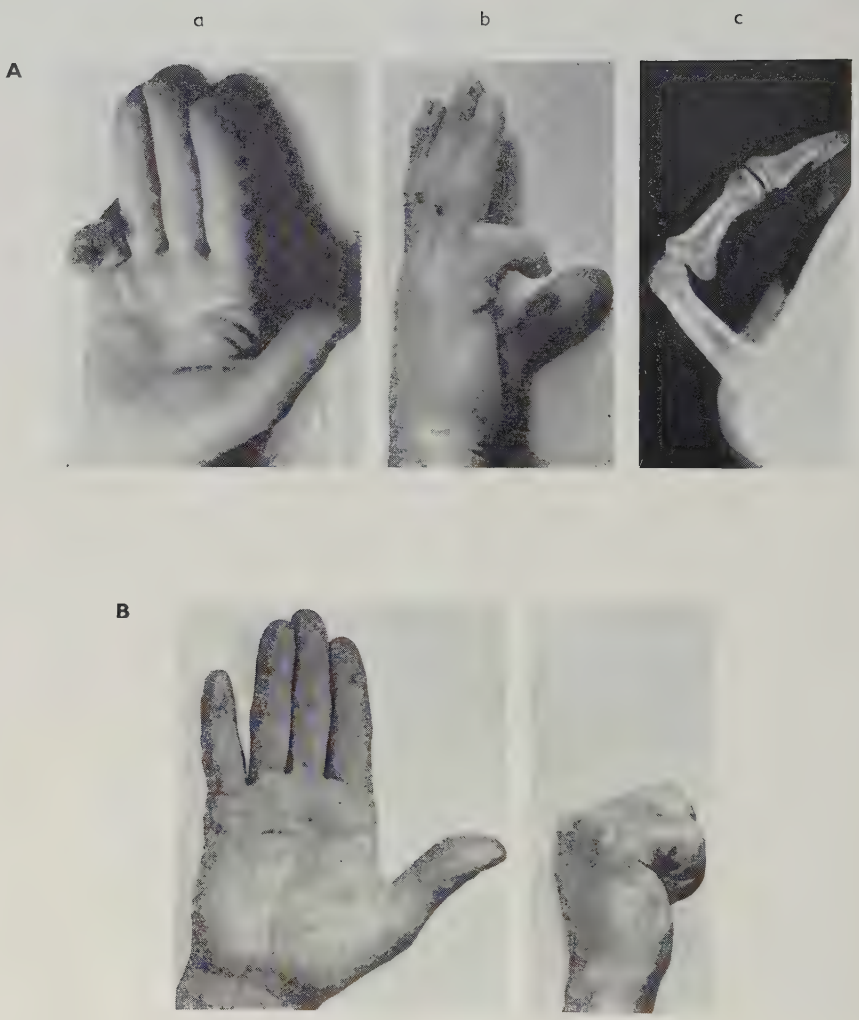


Fig. 48. Case O. M., aged 49. Mechanic. Flexion deformity of right little finger started to develop after wrench of that finger in 1944. One brother also suffered from contracted finger.

20.6.1947. *Operation* (T. S.): Aponeurosectomy according to McIndoe.

A — Condition before operation. Nodular cord in the palm towards the little finger and the proximal interphalangeal joint of this finger has acquired a subluxated position (c). Note the presence of knuckle-pads (b). (Cf. Fig. 36.)

B — 3 months after operation: function normal. Scars from Z-plastic hardly visible. (The patient returned to hard work 6 weeks after the operation.)

A

B

Fig. 49. Case L. H. aged 45. Army-officer. Unilateral Dupuytren's contraction, which started to develop after blunt trauma to the left hand in 1942. Maternal uncle similarly affected.

29.3.1947. *Operation* (T. S.): Aponeurosectomy according to McIndoe.

A — Condition before operation. Typical retraction of the ulnar part of the palmar aponeurosis causing dimples and furrows in the palm. Little finger flexed to 45 degrees at the metacarpophalangeal joint. Ring and middle fingers less affected. Grade II.

B — 2 months after operation. (Complete restoration was achieved 6 weeks after the operation.)

Fig. 50. Case U. B., aged 46. Clerk. Unilateral Dupuytren's contraction developing for about 20 years. Cause unknown. Father and one brother both suffered from similar hand deformity.

20.11.1946. *Operation* (T. S.): Aponeurosectomy according to McIndoe.

A — Condition before operation with tendon-like cords in the extension of the ring and little finger. Grade III.

B — 5 months after operation; function normal. (The patient returned to work 6 weeks after the operation.) The scars from the incisions were almost invisible. They are outlined with ink in the palmar aspect to show the results of Z-plastics on ring and little fingers.

2) *Case A. D.*, aged 60. *Right hand:* Severe flexion deformity of 3rd, 4th and 5th fingers, progressing for ten years. Immediate operative result very satisfactory (17.1. 46).

Post-operatively the patient developed periarthritis of the left shoulder joint with vascular disturbances of the hand and stiffness of the finger joints.

2.8. 46. Though the result from a surgical point of view was excellent, the function was slightly impaired as the patient could not flex the fingers freely in the interphalangeal joints. This must, however, chiefly be regarded as a sequela to the disease of the shoulder joint.

The period during which after-treatment was continued varied considerably according to the degree of severity. In a number of cases splinting at night was used for more than six months. This did not prevent the patients starting light work as soon as they were soundly healed.

The case shown in Fig. 50 belongs to this grade.

Grade IV (9 cases). — *The results were excellent in 3 cases.* Some flexion deformity remained in all these cases. It was confined to the proximal interphalangeal joint of the little finger and did not restrict the function of the hand.

The results were fair in 6 cases. If the results are judged on the basis of the severe changes present before the operation, the results were excellent. The palm and the metacarpophalangeal joints were in an entirely satisfactory condition. The function of the fingers was not, however, fully restored owing to severe pathological changes in the interphalangeal joints. The patients were, nevertheless, able to grip well and were satisfied with the considerable functional improvement brought about by the operation.

If the cases in the various grades are amalgamated, the results were excellent in 83 per cent and fair in 17 per cent. These results must be considered as extremely gratifying since more than half the hands operated on were in advanced stages of the disease (Grades III and IV). A comparison with the results in other series is difficult, since these usually contain no statement of the result of the operation in relation to the degree of severity present before operation. Such a comparison is only found in von Stapelmohr's material. All his patients (Table 12) belonged to Grades I and II.

There was no recurrence in any of the cases although normally there is moderate thickening of the palm during a few months after

TABLE 12

Results of Complete Excision of the Palmar Aponeurosis

Author	Hands after-examined	Excellent		Fair		Poor	
		Number	Per-centage	Number	Per-centage	Number	Per-centage
Kanavel et al (1929)..	27	20	74	5	19	2	7
Wagner (1932)	20	12	60	7	35	1	5
Desplas, Meillère (1932)	8	5	62	3	38	—	—
Meyerding (1936)	74	55	74	11	15	8	11
Gerritzen (1936).....	19	15	78	2	11	2	11
Einarsson (1946)	62	43	69	7	11	12	20
von Stapelmohr (1947)	28	18	64	8	29	2	7
Writer's material*....	69	57	83	12	17	—	—

* v. Table 11.

aponeurosectomy, which can be misinterpreted as a recurrence. Disappearance of this thickening is spontaneous but can be hastened by massage.

None of the patients mentioned or showed symptoms which could imply that the palmar aponeurosis is essential for perfect function of the hand. Several of the patients were engaged in heavy manual labour. Two patients, however, had a feeling that the palm was "unprotected" and preferred to use gloves in heavy work but they were not dependent on such protection.

The patients stated that normal sensation in the palm returned after approximately three months.

4. Conclusions from the Writer's Material

1. Using the method of operation described, and if no complications arise, perfect anatomical and functional results can be expected in all cases of Dupuytren's contraction in which severe secondary changes in the joints are not present. The operation should, if possible, be performed before such changes have developed.

2. It is possible, even in advanced cases, to achieve considerable improvement by clearing of the palm and freeing of the metacarpophalangeal joints thus opening the hand for gripping. Severe sec-

ondary changes in the interphalangeal joints are less responsive to therapy.

3. Except in rare cases it is possible to retain the palmar skin and to perform the operation from incisions which do not cause secondary contractions.

4. Post-operative haematoma and infection are the chief complications which can retard healing and lead to poorer results.

5. Healing normally takes place within three weeks. Varying periods of after-treatment, depending on the degree of severity of the disease, are then necessary.

6. Rational after-treatment, particularly in advanced cases, is of decisive importance in obtaining satisfactory results. Continuous splinting in extension over long periods should not be allowed under any circumstances since it causes stiffness of the finger-joints. A slightly flexed finger with free flexion capacity is a useful finger, whereas a straight, stiff finger is useless and causes inconvenience.

7. Complete excision of the palmar aponeurosis causes no functional disability.

Summary

Introduction. — Unsolved problems regarding Dupuytren's contraction are briefly outlined. The purpose of the present investigation is stated.

Anatomy and Embryology of the Palmar Aponeurosis. (Chapter I). — A general survey is given of the anatomy of the palmar aponeurosis, mainly based on the writer's dissections, with special reference to the symptomatology and surgical treatment of Dupuytren's contraction. The findings verify those previously made with the exception of the digital extensions of the aponeurosis. These are found to merge with the digital fasciae forming a fascial system shown diagrammatically in Fig. 4, p. 17. Fibres reaching as far as the base of the second phalanx are described.

The function of the palmar aponeurosis is discussed. Its pronounced development on the ulnar aspect is associated with greater functional strain at this site.

The development of the palmar aponeurosis is studied in twenty human embryos and foetuses at various stages. It is stressed that the aponeurosis is formed from several primordia.

Incidence and Symptomatology. (Chapter II). — The incidence of the disease is discussed against the background of an extensive survey of the literature. This shows that Dupuytren's contraction is 6—8 times more common in men than in women. The marked increase in frequency with increasing age is exemplified.

A compilation of 2,200 cases reported earlier in the literature is made. It is possible on the basis of these reports to make more definite statements than earlier with regard to the manifestations of the disease. Thus, for example, it can be established statistically that the right hand is more frequently involved than the left and the ring and little fingers considerably more often than the other fingers (Tables 4 and 5).

Various conditions which might present difficulties in the differential diagnosis are reviewed.

The objective and subjective symptoms are described in a report on 50 cases examined by the writer. It is stressed that the first symptom was a nodular thickening of the palmar aponeurosis.

Pathology and Pathogenesis. (Chapter III). — I. The various opinions on the histological picture in Dupuytren's contraction are reviewed. Though in principle these are in agreement, no generally accepted theory as regards its interpretation is found.

A. The macroscopical changes in the diseased aponeurosis are described from personal observations.

B. A report is given on a microscopical examination of 29 specimens from cases of Dupuytren's contraction. (Sections of the palmar aponeurosis from 10 post-mortem cases served as comparative material.) The nodular thickenings of the diseased aponeurosis are found to correspond to areas of hypercellular connective tissue of various grades of maturity. The writer considers these diffusely defined areas as pathognomonic for the pathohistology of the disease. Structures are demonstrated suggestive of ruptures of the fibre bundles in the aponeurosis at the site of the hypercellular areas. The development of the newly formed connective tissue is followed from the very early stages with fibroblasts and precollagen fibrils to a scar-like fibrous stage. The demonstration of iron pigment within these areas is of particular interest. The tendon-like cords of the diseased aponeurosis are found to consist of compact collagen tissue. Its stainability is studied by various methods; *inter alia* pronounced metachromasia is reported.

A description of concomitant changes in the palmar skin is given.

Sections of a finger joint with advanced flexion deformity of long standing show that the articular cartilage retained its normal appearance in parts which were articulated, whereas elsewhere it was absorbed. The articular surfaces were deformed.

C. Electron microscope studies are reported showing that the average width of collagen fibrils from the tendon-like cords of the diseased aponeurosis is greater than that of fibrils from a palmar aponeurosis of normal appearance. The difference (about 10 per cent) is statistically significant. Differences in the characteristic cross-

striated structures of the collagen fibrils between the two materials are also reported. The significance of these findings are discussed.

II. From observations made regarding the pathology in Dupuytren's contraction the writer advances a theory concerning the pathogenesis of the disease, i. e. that the deformity arises in the first instance as the result of partial ruptures in the aponeurotic tissue. It is demonstrated experimentally that such ruptures can occur. The presence of iron pigment in the newly formed connective tissue is considered as strong support for the theory as this can with all probability be interpreted as remains of small haemorrhages.

Various courses of development according to this pathogenetic theory are envisaged and it is found that all the clinical features of the disease can be explained in this way. The evident correlation of the condition to increasing age would also be explained naturally since the physico-chemical changes accompaning aging increase the possibility of ruptures of the connective tissue.

Several reasons are given in support of this theory comprising clinical observations, histological and electron microscope findings.

The skin changes are regarded as secondary to the process in the aponeurosis and the changes of the finger joints as due to the abnormal positions they have acquired.

"*Dupuytren's Contraction*" *of the Plantar Aponeurosis* (Chapter IV). — 1. The anatomy of the plantar aponeurosis is reviewed and the writer reports on 40 dissections. From this investigation digital extensions to the four lateral toes are described analogous to those in the hand. At the site of predilection of the pathological process concerned — the medial border of the plantar aponeurosis in the hollow of the foot — two vertical bands are demonstrated which fix the aponeurosis tensely to the skeleton. They have an obvious functional significance.

A study of the embryology of the plantar aponeurosis is based on material mentioned in Chapter I.

2. The writer has attempted to give a complete survey of cases reported earlier in which both the palmar and plantar aponeuroses were involved. In all these cases the process in the plantar aponeurosis was limited to its medial portion in the hollow of the foot.

In 43 patients suffering from Dupuytren's contraction of the hands

the writer found that in 18.6 per cent the plantar aponeurosis was also involved, the localization consistently being that mentioned above. The symptomatology, illustrated by case reports, is discussed.

3, 4. The microscopical characteristics of the process in the foot are described and considered to support the writer's theory concerning the pathogenesis of Dupuytren's contraction. Further evidence is found in the fact that the pathological changes occur typically at a site of particular strain on the plantar aponeurosis, i. e. in its most arched, medial part. The bands which attach the aponeurosis at this point are regarded as evidence of this assumption. Some aetiological factors are discussed.

5. The treatment when the plantar aponeurosis is involved is considered.

Dupuytren's Contraction in Relation to Some Similar Changes in Connective Tissue (Chapter V). - A review is made of the scanty literature on *knuckle-pads* (subcutaneous nodules on the dorsal aspect of the proximal interphalangeal finger joints). The writer is able to demonstrate that knuckle-pads are common in patients with Dupuytren's contraction. In 50 patients examined the occurrence was 44 per cent, whereas the frequency in control material was 2.6 per cent only. A detailed account is given of the clinical characteristics of this condition.

On excision of typical knuckle-pads in three cases it was found that the fibrous nodules were localized to the extensor mechanism of the fingers. The microscopical picture of such specimens is reported as identical with the typical tissue changes in the palmar aponeurosis of patients with Dupuytren's contraction; a fact not previously substantiated. Reasons are given why both deformities should be regarded as signs of the same condition.

The writer's theory regarding the pathogenesis of Dupuytren's contraction is also applied to knuckle-pads.

Theories advanced presuming a relationship between Dupuytren's contraction and *induratio penis plastica* or *keloids* or *muscular torticollis*, etc. are considered. Neither a critical review of the literature on this subject nor the writer's material is found to permit any definite conclusions.

Dupuytren's Contraction and Epilepsy (Chapter VI). — Lund's observations of an abnormally high frequency of Dupuytren's contraction in epileptics is confirmed by the writer. In 207 male epileptics examined a frequency of 42 per cent is reported. The occurrence of similar changes in the plantar aponeurosis, knuckle-pads and induratio penis plastica in this material, reported in previous chapters, is seen from Table 7, p. 99.

Contrary to Lund, the writer regards the marked tendency to finger contraction in epileptics independent of epilepsy itself. Several facts are mentioned in support of the theory that this tendency can be acquired by such patients and that it may possibly be connected with lengthy administration of phenobarbital.

Aetiology (Chapter VII). — I. Statistics from the literature indicate that the disease is hereditary; dominance as well as recessivity is assumed. In the writer's 50 cases familial occurrence was stated in 44 per cent. The figures obtained are considered to depend on dominant heredity with low penetrability.

II. The vast number of theories regarding the aetiology of Dupuytren's contraction are assembled in a critical survey. The writer's material definitely contradicts the majority of them.

III. The writer's well supported view on the pathogenesis of the disease and clinical observations, especially as regards its manifestation in the plantar aponeurosis, are considered to indicate a traumatic causal factor. It is emphasized, however, that trauma alone cannot be decisive, as all individuals are exposed to trauma to a greater or lesser extent. That this does not exclude the possibility that trauma is the causal factor in cases with predisposition to the disease is found to be supported by the fact that there is an increased frequency among persons engaged in heavy manual work, and that the right hand is more frequently involved than the left. The relatively limited influence of occupational trauma on the general frequency of the disease is assumed to demonstrate the fundamental importance of individual predisposition. The predisposing factor is regarded usually to be inherited but the frequent occurrence of finger contraction in epileptics seems to suggest that it can also be acquired.

The writer regards Dupuytren's contraction as a result of general patho-physiological reactions in the connective tissue and finds this

view supported by the fact that identical tissue changes occur outside the palmar aponeurosis.

Treatment (CHAPTER VIII). — I. An extensive review is made of non-operative and operative methods of treatment in Dupuytren's contraction. The experience of X-ray and radium therapy in 149 cases is reported.

II. A detailed, illustrated description of an operative method elaborated by Sir Archibald McINDOE is given. Its principles are complete excision of the palmar aponeurosis from incisions not causing disabling scarring. Z-plastics are performed on the contracted fingers.

Stress is laid upon methodical after-treatment, of which the principles are given.

50 patients (68 hands) treated according to this method are reported on. The material is classified into four grades according to the degree of deformity present before the operation, and the results are given for each grade (Table 11, p. 161). If all the cases are considered together the results were excellent in 83 per cent and fair in 17 per cent. These figures are the best hitherto reported and are considered as extremely gratifying since most cases were in advanced stages.

Conclusions are made on the treatment employed.

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NOTE

Pages 43, 44, 45, 60: "Weigert's iron haematoxylin" should be "**Heidenhain's** iron haematoxylin"

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